Analysis of the Correlation between the Mental Stress of College Students and Their Learning Initiative during the Outbreak of COVID-19

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Abstract—The spread of COVID-19 has brought negative impacts on the life and study of college students and thus aggravated their mental stress in this environment. Existing research has focused more on the status quo of the problem while having ignored its process variability, and there is no research on the correlation between the mental stress of college students and their learning initiative during the outbreak of COVID-19. To this end, this paper conducts an analysis of the correlation between the mental stress of college students and their learning initiative during the outbreak of COVID-19. In-depth analysis was carried out by the factor analysis method in SPSS, and an evaluation model was built for the mental stress of college students during the outbreak of COVID-19 based on four stressors, with the process of how to obtain the evaluation results given. The grey correlation analysis method was used to quantitatively analyze the correlation between the mental stress of college students and their learning initiative during the outbreak of COVID-19, that is, the factors affecting college students' learning initiative during the outbreak of COVID-19 were investigated through the grey correlation analysis. Finally, the relevant experimental results were given.

Keywords—COVID-19 outbreak, mental stress of college students, learning initiative, correlation analysis

1 Introduction

Since the end of 2019, all parts of the world have been affected to varying degrees by the COVID-19 pandemic. Offline economic activities have come to a standstill, and people's lifestyles and activities have been restricted as never before [1–8]. Against the backdrop of the pandemic, colleges and universities in various areas have implemented management reform measures, including repeatedly postponing the opening of school terms and vacation time, implementing the remote teaching and classroom management systems, and restricting students' gatherings and travels outside campuses to deal

with the possible spread of the pandemic [9–16]. The college period is an important transition stage for students as they will step into the society from this place. Faced with the learning and employment stress, college students are prone to various psychological problems [17–19]. Now with the negative impacts of COVID-19 on their life and study, their mental stress has been obviously aggravated in this environment [20–24]. Therefore, to stabilize the quality of talent training in colleges and universities, it is necessary to study the changes in the mental stress and learning status of college students during the outbreak of COVID-19.

Education is one of the hardest hit sectors by the outbreak of COVID-19. Educators and students around the world are being forced to turn to online teaching and learning. Students, in particular, have been psychologically affected and encountered difficulties in learning due to the lockdown imposed by the government to control the pandemic. Atlam et al. [25] used statistical and machine learning methods to study the impact of the COVID-19 pandemic on the educational system, especially the mental health of college students. The questionnaires were distributed to college students in three Arab countries: Egypt, Jordan and Saudi Arabia. A total of 1766 responses were returned and analyzed using statistical and machine learning methods. The results show a clear correlation between students' mental health and the use of online education during the outbreak of COVID-19. Paul et al. [26] mentioned that the spread of COVID-19 pandemic in 2020 not only affected the physical health of individuals, but the fear and anxiety about the disease also caused people's mental distress. Therefore, the research developed a new coping strategy to increase individuals' resilience to the outbreaks. Study 1 (N = 210) and Study 2 (N = 93) show that using an avatar to represent oneself in a social virtual world (SVW) had a significant beneficial effect on one's resilience against COVID-19. The virtual learning environment during the pandemic has made it possible to support the initial face-to-face model of education at all levels. Teaching and learning require educational strategies that enable classrooms to enter the virtual world and be as effective as face-to-face environments. Llerena-Izquierdo [27] developed a virtual classroom design model that positively affected participants' motivation and performance. In two courses of the first academic period for engineering at the Salesian Polytechnic University in Guayaquil, the analysis identified the relationships between the virtual classroom design and sequence, graphic lines, formats and amount of resources, and the participants' motivation and performance. It was concluded that this design had a positive impact on the learning activities of students, making it more meaningful to students relative to its presentation, and that it created a sense of ownership and belonging for the participants due to its immediate comprehension and ease of implementation. Abi Darmawan et al. [28] aimed to analyze the motivation of students to study online during the COVID-19 pandemic. Highly motivated students learn more easily than less motivated ones. In online learning, students' motivation is critical as it is key to students' understanding of the subject material, but many factors can reduce

their motivation. The aim of Fajri et al. [29] was to determine the effectiveness of online learning as an alternative solution to the students' learning activities at Nurul Jadid University during the COVID-19 pandemic. Descriptive qualitative research methods and survey techniques were employed. Tools used included observations, questionnaires and online interviews, through which, whether students' motivation and interest were improved in learning could be found out.

Through review of the existing research at home and abroad, it can be found that the researchers have focused more on the status quo of the mental problem of college students during the outbreak of COVID-19 while having ignored its process variability, and there is no research on the correlation between the mental stress of college students and their learning initiative during the outbreak. To this end, this paper conducts an analysis of the correlation between the mental stress of college students and their learning initiative during the outbreak of COVID-19. Section 2 conducts an in-depth analysis using the factor analysis method in SPSS, and builds an evaluation model for the mental stress of college students during the outbreak of COVID-19 based on four stressors, and also shows the process of how to obtain the evaluation results. Section 3 uses the grey correlation analysis method to quantitatively analyze the correlation between the mental stress of college students and their learning initiative during the outbreak of COVID-19, that is, it investigates the factors affecting college students' learning initiative during the outbreak of COVID-19 through the grey correlation analysis. Finally, this paper gives the relevant experimental results.

2 Construction of the mental stress evaluation model

This paper measured the mental stress of college students during the outbreak of COVID-19, and designed a corresponding indicator system, trying to make it comprehensive but also focused, feasible but also representative, and scientific but also systematic.

During the outbreak of COVID-19, the mental stress of college students come from four aspects, namely academic stress, physical health stress, financial stress, and interpersonal stress. Academic stress mainly involves stress in academic performance, adaptation to online learning form and content, online learning supervision, and assessment; physical health stress mainly comes from the fear of infection with COVID-19 and the difficulty in seeking medical treatment for other diseases; financial stress mainly comes from the increase in daily expenses caused by rising prices during the outbreak and strained sources of household income; and interpersonal stress involves the relationships with teachers, other students, and other school administrators. Figure 1 shows the structure of the questionnaire regarding the changes in college students' learning initiative.

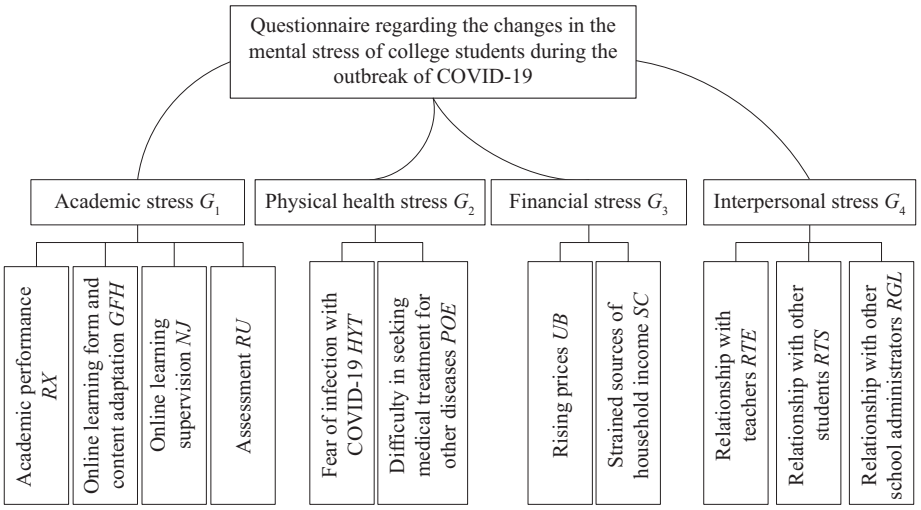

Fig. 1. Structure of the questionnaire regarding the changes in the mental stress of college students

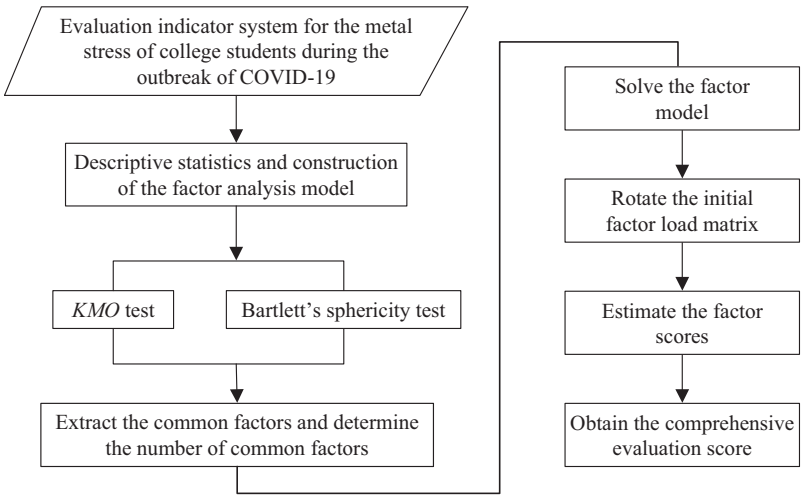

Fig. 2. Process of how to obtain the evaluation results

In this paper, the factor analysis method in SPSS was used for in-depth analysis, and based on the above indicators, an evaluation model was established for the mental stress of college students during the outbreak of COVID-19. Figure 2 shows the process of how the evaluation results are obtained.

In the factor analysis model, the observed variable corresponding to each evaluation indicator is represented by a_i, the serial number of each evaluation indicator by i, the standardized variable of the observed variable by C_i, the common factors that appear

in each variable by G_1, G_2, G_3, …, G_n, the serial number of the factor by j, where j = 1, 2, ……, $n(n \le z)$, the unique factor held by each corresponding variable a_i by a_i, and the unique factor load by the coefficient x_i, the random term by α_i, and the coefficient of the i-th variable on the j-th common factor is represented by x_{ij}, which is also the factor load. The factor load matrix constructed based on x_{ij} is represented by $X = [x_{ij}]$.

Based on the linear weighted sum of N common factors and 1 unique factor, the observed variables corresponding to the above Z evaluation indicators in the established model are characterized, as follows:

$$C_i = x_{i1}G_1 + x_{i2}G_2 + x_{i3}G_3 + \ldots + x_{in}G_n + x_i\alpha_i \tag{1}$$

$$I = 1,2,\ldots,z \tag{2}$$

In order to determine whether the evaluation indicator data are suitable for factor analysis, it is necessary to carry out *KMO* test and Bartlett's sphericity test on the constructed mental stress evaluation model. After the tests, extract the common factors and determine their number. Assuming that the variance of common factors is represented by the variable C_i, the sum of the squares of the elements in each row of the factor load matrix can be calculated by the following formula:

$$f_{2i} = x_{i1}^2 + x_{i2}^2 + \ldots\ldots + x_{in}^2 \tag{3}$$

Next, solve the initial factor load matrix X, that is, obtain the initial solution of the following factor coefficients:

$$\begin{pmatrix} C_1 \\ C_2 \\ \cdots \\ C_z \end{pmatrix} = X \times \begin{pmatrix} G_1 \\ G_2 \\ \cdots \\ G_z \end{pmatrix} \tag{4}$$

Assuming that the eigenvector is represented by V_{ij}, and that the correlation coefficient matrix of the observed variables by S, normalize V_{ij} based on the matrix S, i.e.:

$$O_{ij} = \frac{1}{\left|V_{ij}\right|} * V_{ij} \tag{5}$$

Then multiply O_{ij} in the above equation by $(\mu_i)^{1/2}$ to obtain X:

$$X_{ij} = O_{ij} * \sqrt{\mu_i} \tag{6}$$

During the outbreak of COVID-19, the actual situation of the mental stress of college students is more complicated. In order to explain it accurately, X needs to be rotated. After the relationships between the factors and the observed variables corresponding to the evaluation indicators are redistributed, the main distributions of the 4 common factors, namely academic stress G_1, physical health stress G_2, financial stress G_3, and interpersonal stress G_4 are defined as follows: G_1 includes academic performance RX,

adaptation to online learning form and content *GFH*, online learning supervision *NJ*, and assessment *RU*; G_2 includes fear of infection with COVID-19 *HYT*, and difficulty in seeking medical treatment for other diseases *POE*; G_3 involves stress in daily expenses *UB* and *SC* due to the rising prices during the outbreak and the strained sources of household income; and G_4 includes the relationship with teachers *RTE*, the one with other students *RTS*, and the one with other school administrators *RGL*.

In the analysis and solution of actual mental stress problem of college students during the outbreak of COVID-19, the Thomson factor score can be used to estimate the factor score. Perform regression with the observed variables corresponding to the *z* evaluation indicators, and the constructed regression equation is given as follows:

$$G_j = \rho_{j0} + \rho_{j1}x_1 + \rho_{j2}a_2 \ldots\ldots + \rho_{jz}a_z \tag{7}$$

Based on the least squares estimate method, the factor score coefficient matrix *Y* can be calculated as follows:

$$Y = X'S^{-1} \tag{8}$$

X' represents the transpose of the rotated factor load matrix when the factors are orthogonal, and the transpose of the factor structure matrix when the factors are diagonal. The normalized matrix of the observed variables corresponding to the evaluation indicators is represented by *C*. Based on *Y* and *C*, the estimated value of the factor score can be obtained by the following equation:

$$G_j = Y * C \tag{9}$$

According to *Y*, the scores of the four common factors after rotation can be expressed as follows:

$$\begin{aligned} G_1 &= 0.051RX + 0.197GFH + 0.019NJ \\ &- 0.051RU + 0.115HYT - 0.164POE - 0.147UB \\ &- 0.023SC + 0.306RTE + 0.194RTS + 0.066RGL \end{aligned} \tag{10}$$

$$\begin{aligned} G_2 &= 0.219RX - 0.049GFH - 0.153NJ \\ &+ 0.31RU + 0.166HYT + 0.017POE + 0.164UB \\ &+ 0.34SC + 0.087RTE - 0.011RTS + 0.047RGL \end{aligned} \tag{11}$$

$$\begin{aligned} G_3 &= -0.121RX - 0.042GFH + 0.576NJ \\ &- 0.046RU - 0.058HYT - 0.053POE + 0.647UB \\ &+ 0.017SC - 0.067RTE - 0.163RTS + 0.276RGL \end{aligned} \tag{12}$$

$$\begin{aligned} G_4 &= -0.184RX - 0.227GFH + 0.341NJ \\ &- 0.204RU + 0.217HYT + 0.109POE + 0.227UB \\ &+ 0.034SC - 0.053RTE - 0.237RTS - 0.077RGL \end{aligned} \tag{13}$$

To sum up, the level of mental stress of college students during the outbreak of COVID-19 can be properly expressed only with the common factors, namely academic stress G_1, physical health stress G_2, financial stress G_3, and interpersonal stress G_4, taken into account. Set the weight of each of the four common factors based on their variance contribution rates, and then multiply the weights by Y, which is calculated by *SPSS,* to obtain the comprehensive score of the mental stress of college students during the outbreak of COVID-19, i.e.:

$$G = 0.4451G_1 + 0.3127G_2 + 0.1307G_3 + 0.1115G_3 \tag{14}$$

3 Correlation analysis between mental stress and learning initiative

Next, this paper used the grey correlation analysis method to quantitatively analyze the correlation between the mental stress of college students and their learning initiative during the outbreak of COVID-19, that is, it used the grey correlation analysis to analyze the factors that affect the learning initiative of college students during the outbreak of COVID-19.

First, set the comparative sequences and the reference sequence, and take the learning initiative of college students during the outbreak of COVID-19 as the "reference value", that is, the parent sequence:

$$a_0 = \{a_0(l) \mid l = 1, 2, \ldots, 15\} \tag{15}$$

The comparison sequences involve the 4 influencing factors to the mental stress of college students during the outbreak of COVID-19. Take the four common factors G_1, G_2, G_3 and G_4 and a comprehensive factor G representing the mental stress level of college students during the outbreak of COVID-19 as 4 evaluation items to study the relationships between G_1, G_2, G_3, G_4 and G and college students' learning initiative. Since 11 indicators are involved, with great differences in their dimensions, the quantitative values of the indicators are non-dimensionalized as follows to avoid impacts on the results of the correlation analysis:

$$A_i(l) = \frac{a_i(l) - \min a_i(l)}{\min a_i(l) - \min a_i(l)} \tag{16}$$

Assuming that the correlation coefficient between the l-th indicator of the i-th object and the l-th indicator in the reference sequence is represented by $\delta_i(l)$, and that the resolution coefficient by γ, the grey correlation coefficient value $\delta_i(l)$ is calculated according to the following equation:

$$\delta_i(l) = \frac{min(i)\,min(l)\left|A_0(l) - A_i(l)\right| + \gamma\, min(i)\,min(l)\left|A_0(l) - A_i(l)\right|}{\left|A_0(l) - A_i(l)\right| + \gamma\, min(i) min(l)\left|A_0(i) - A_i(l)\right|} \tag{17}$$

Finally, the correlations between G_1, G_2, G_3, G_4 and G and college students' learning initiative is calculated based on the following equation, and all evaluation objects are sorted:

$$s_i = \frac{1}{m}\sum_{i=1}^{m}\delta_i(l) \tag{18}$$

The larger s_i is, the more consistent the variation trends of the comparison sequence $A_i(l)$ and the reference sequence $A_0(l)$ are, indicating that the mental stress of college students has a great impact on their learning initiative during the outbreak of COVID-19.

4 Experimental results and analysis

Table 1. Rotated factor load matrix

	G_1	G_2	G_3	G_4
RX	0.051	0.219	−0.121	−0.184
GFH	0.197	−0.049	−0.042	−0.227
NJ	0.019	−0.153	0.576	0.341
RU	−0.051	0.31	−0.046	−0.204
HYT	0.115	0.166	−0.058	0.217
POE	−0.164	0.017	−0.053	0.109
UB	−0.147	0.164	0.647	0.227
SC	−0.023	0.34	0.017	0.034
RTE	0.306	0.087	−0.067	−0.053
RTS	0.194	−0.011	−0.163	−0.237
RGL	0.066	0.047	0.276	0.077

Table 1 presents the rotated factor load matrix, which represents the effect of each evaluation indicator on the four common factors. Table 2 shows the ranking of the common factor scores for the mental stress of college students during the outbreak of COVID-19.

Figure 3 shows the distribution of the total scores for the mental stress of college students before and after the outbreak of COVID-19. It can be seen directly from the above figure that the total scores of the questionnaires regarding the mental health of college students before and after the outbreak showed a positive skewed distribution. The scores of the mental stress of college students ranges between [0,12]. The median total score of the mental health of college students before the outbreak was 2 points, while that after the outbreak was 9. Before and after the outbreak, the detection rates of suspected mental disorders among 460 college students were 6.47% and 22.48%, respectively.

Table 2. Ranking of the common factor scores for the mental stress of college students during the outbreak of COVID-19

Sample No.	G_1	G_1's Ranking	G_2	G_2's Ranking	G_3	G_3's Ranking	Score	Ranking
1	0.95828	12	0.26195	1	1.52748	10	0.75	9
2	−0.0352	5	2.51741	6	−0.8624	6	0.63	1
3	1.34728	10	0.36295	12	−0.859	3	0.69	5
4	0.81592	6	−0.3528	8	1.32684	11	0.55	7
5	1.32491	2	−0.3415	10	−0.7481	15	0.41	12
6	−0.1529	13	0.52837	9	0.79586	1	0.32	2
7	0.92518	7	−0.8596	2	0.21052	7	0.14	4
8	0.46251	11	−1.3521	14	0.63825	9	−0.06	10
9	0.0361	9	−0.3817	5	−1.247	13	−0.35	11
10	−0.458	1	−0.4628	3	−0.2615	2	−0.42	3
11	−0.7958	3	0.06329	13	−1.6352	12	−0.58	14
12	−1.3527	8	−0.4571	4	0.85726	5	−0.51	6
13	−1.6925	15	−0.1629	7	−0.6519	8	−0.74	13
14	−1.0272	4	−0.9852	11	0.63524	4	−0.76	15
15	−0.7586	14	−0.8649	15	−0.7158	14	−0.82	8

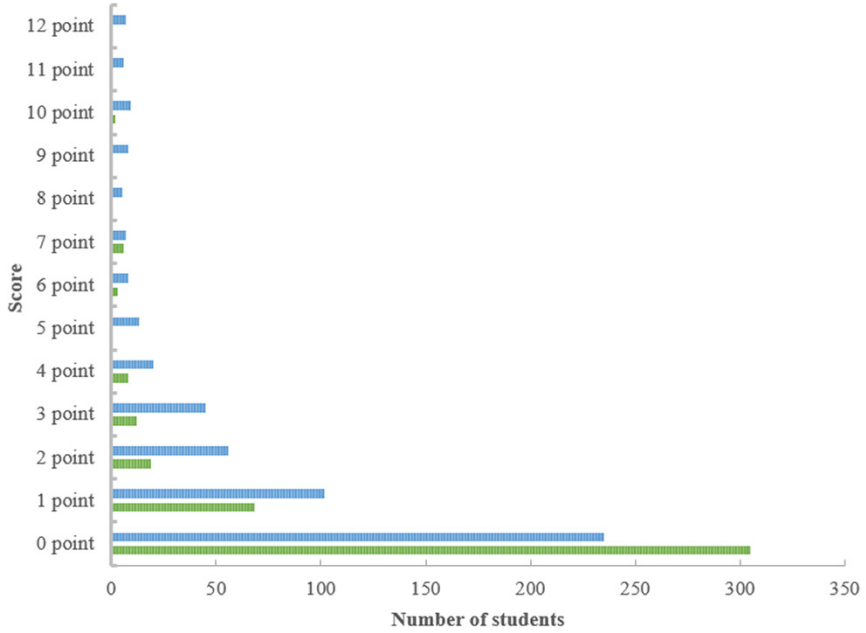

Fig. 3. Distribution of the total scores for the mental stress of college students before and after the outbreak of COVID-19

Only the impacts of the evaluation indicators regarding the mental stress of college students on their learning initiatives during the outbreak of COVID-19 were taken into account. The learning initiative was used as the dependent variable, and the academic performance *RX*, adaption to online learning form and content *GFH*, online learning supervision *NJ*, assessment *RU*, fear of infection with COVID-19 *HYT*, difficulty in seeking medical treatment for other diseases *POE*, stress in daily expenses *UB* caused by rising prices and strained sources of household income SC, relationship with teachers *RTE*, relationship with other students *RTS* and relationship with other school administrators *RGL* as independent variables. Regression analysis was performed with the software SPSS to analyze the impacts of the mental stress evaluation indicators of college students on their learning initiative during the outbreak of COVID-19. Table 3 presents the regression analysis results.

Table 3. Regression analysis on the mental stress of college students and their learning initiative

Model	Non-Normalized Coefficient		Normalized Coefficient	*t*	Significance
	B	**Standard Error**	***Beta***		
(Constant)	3.258	0.285	0.362	13.628	0.425
RX	0.251	0.048	0.174	2.104	0.241
GFH	0.062	0.041	−0.129	1.629	0.395
NJ	−0.027	0.052	−0.185	−1.528	0.537
RU	−0.035	0.069	−0.128	−1.958	0.485
HYT	−0.019	0.018	0.184	−1.625	0.641
POE	0.021	0.057	−0.038	0.859	0.395
UB	−0.038	0.036	0.027	−0.641	0.328
SC	0.062	0.031	0.061	0.258	0.447
RTE	0.048	0.076	0.035	0.131	0.513
RTS	−0.097	0.051	−0.047	−0.028	0.251
RGL	0.015	0.047	0.016	−0.028	0.147
R-squared			0.062		
Value of the F-statistic			8.147		
Significance level			0.036		

Table 4. Calculation results of the four metrics of the evaluation indicators

Four Metrics / Indicator	Effect Degree	Effected Degree	Centrality	Cause Degree
RX	0.847	0.025	0.847	0.875
GFH	1.326	0.014	1.629	1.613
NJ	1.258	0.195	1.374	1.509
RU	1.362	0.417	0.748	0.162
HYT	0.591	0.238	0.713	0.237

(Continued)

Table 4. Calculation results of the four metrics of the evaluation indicators *(Continued)*

Four Metrics / Indicator	Effect Degree	Effected Degree	Centrality	Cause Degree
POE	0.628	0.014	0.658	0.612
UB	0.847	0.069	0.916	0.718
SC	0.741	1.352	1.429	−0.463
RTE	0.362	1.057	2.517	−1.279
RTS	0.025	2.314	2.629	2.457
RGL	0.115	1.037	0.110	0.073

From the regression analysis results, it can be seen that during the outbreak of COVID-19, the evaluation indicators regarding the mental stress of college students had significant impacts on students' learning initiatives. The reason may be that college students who could not enjoy normal college life always felt stressed and depressed, and had a higher incidence of mental disorders. Among the mental health problems of college students during the outbreak of COVID-19, "frustration", "anxiety/depression", "insomnia" and "restlessness" were quite prominent. These mental issues brought by such stresses led to a decline in students' learning initiative.

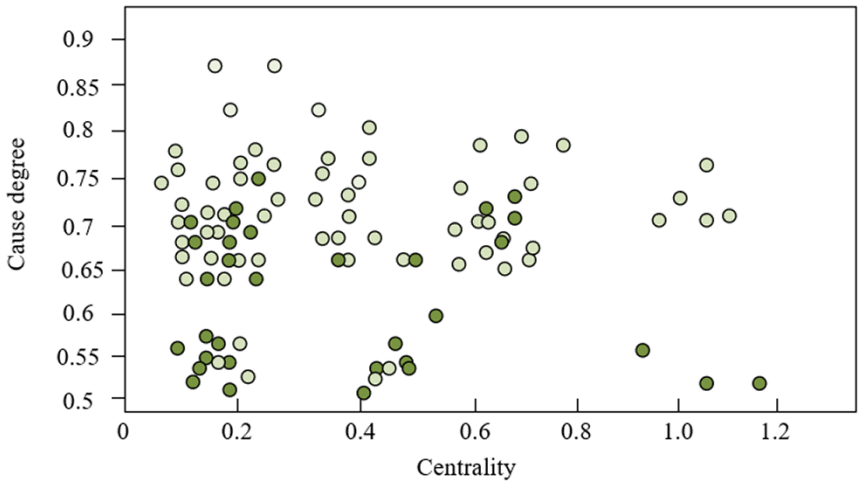

Fig. 4. Relationship between the centrality and cause degrees of different samples

In order to further explore the effect relationships and degrees of the mental stress evaluation indicators of college students with and on their learning initiative during the outbreak of COVID-19. Table 4 presents the calculation results of the four metrics of the evaluation indicators. The four metrics are namely effect degree, effected degree, centrality and cause degree. The adaptation to online learning form and content *GFH* and assessment *RU* have high effect degrees, and the stress in daily expenses caused by strained sources of household income *SC*, the relationship with teachers *RTE*, the relationship with other students *RTS* and the relationship with other school administrators *RGL* have high effected degrees. The adaptation to online learning form and content

GFH, the assessment *RU* and the stress in daily expenses caused by strained sources of household income *SC* have great centrality values, indicating that these three indicators are more important. There are more evaluation indicators with a cause degree of greater than 0, which further verifies the significant effects of the mental stress evaluation indicators on students' learning initiative.

Figure 4 shows the relationships between the centrality and cause degrees of the evaluation indicators. It can be seen that there are many samples with high centrality and cause degrees, which further shows that the evaluation indicators of the mental stress of college students during the outbreak of COVID-19 play very important roles in their learning initiative.

5 Conclusions

This paper conducted an analysis of the correlation between the mental stress of college students and their learning initiative during the outbreak of COVID-19. An in-depth analysis was carried out by the factor analysis method in SPSS, and an evaluation model was built for the mental stress of college students during the outbreak of COVID-19 based on four stressors, with the process of how to obtain the evaluation results given. The grey correlation analysis method was used to quantitatively analyze the correlation between the mental stress of college students and their learning initiative during the outbreak of COVID-19, that is, the factors affecting college students' learning initiative during the outbreak of COVID-19 were investigated through the grey correlation analysis. Finally, the rotated factor load matrix and the score ranking of some common factors regarding the mental stress of college students during the outbreak of COVID-19 were given. The distributions of the total scores of the mental stress of college students before and after the outbreak of COVID-19 were summarized. Regression analysis was performed using the software SPSS to analyze the effects of the mental stress evaluation indicators of college students on their learning initiative during the outbreak of COVID-19, with the regression analysis results given. Four metrics, namely effect degree, effected degree, centrality and cause degree, about the evaluation indicators were calculated, to further explore the effect relationships and degrees of the mental stress evaluation indicators of college students with and on their learning initiative during the outbreak of COVID-19. Finally, the relationships between the centrality and cause degrees of the evaluation indicators were shown.

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