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Using Grey S-P Chart to Evaluate English Reading Performances

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Abstract. The purpose of this paper is to apply an integrated approach to evaluate the English reading performances among college students because finding the optimal teaching strategy for an individual student is difficult. The unified English reading exam with forty questions was used to clarify the different performances between day-time and extension classes which have thirty-eight students and thirty-seven students, respectively. The GSP (Grey Student-Problem) chart, which includes the equation of Rasch model, was then generated by coding the data into the S-P (Student-Problem) chart, and using the GRA (Grey Relational Analysis) method. The results indicate that the teachers could provide adaptive teaching methods and remedial instructions based on the graphic models. Also, parents could understand their children's learning conditions better by reading the clear graphs. We suggested that the GSP chart can not only be applied to the educational field, but also be used in real-life applications, like medical data analysis, engineering, or decision-making fields.

Keywords: English reading performances, optimal teaching strategy, GSP chart, SP chart, GRA.

1. Introduction

When entering universities in Taiwan, freshman students are asked to take the "Freshman English" course for one academic year, and the main focus of the course is to improve students' four language skills (listening, reading, writing and speaking), and reading comprehension is highly emphasized among them [1]. However, for the students with poor English reading skills, they may recognize the English articles as the combination of single words instead of recognizing it as a meaningful content [2]. Therefore, the paper aims to apply the Grey Student-Problem chart (GSP chart) to evaluate the freshman students' English reading performances on the unified exam, and classify them into appropriate groups in ESL classrooms in the university in central Taiwan [3,4]. By doing this, we hoped that the English teachers can avoid the situation of focusing on the more advanced students while ignoring the less able ones.

There are many researches indicate that both the response pattern of the students, and the caution index of the S-P chart could classify students into different groups [3~7]. However, there is limitation to S-P chart because the data are coded in either 0 or 1 instead of using the real ones. Besides, the line graph in the S-P chart is shown vertically, and each test-taker or question has its fixed space, that is, a line or distance. According to Professor Nagai, the misconception will occur when most students get the correct answer on the same question due to the S-P chart presents many line graph spaces instead of showing the line graph based on the real data [8]. Owing to the limitations of S-P chart, Nagai developed Grey S-P chart (GSP) which could be used for evaluating and clustering students' performances by using the real data [8].

In this paper, the GSP was used to cluster students' reading performances. In section 2, we introduce the GRA and GSP models, and in section 3, we provide an example of English reading exams to verify our point.

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Then in section 4, we make some suggestions for the further research in our study, that is, the English teachers can understand the concept diagnosis, and provide different remedial instructions to their students, and this could help the adaptation to individual differences.

2. Method

In this section, we only introduce the methods of GRA and GSP briefly.

2.1. Grey Relational Analysis

The grey relational analysis (GRA), which can deal with the uncertain, multiple, discrete and incomplete data effectively, is a method in grey system theory [9,10]. Steps of GRA generation are described as follows [9~15].

First, establish the reference vector (1) and the comparative vector (2):

$$x_0 = (x_0(1), x_0(2), \cdots, x_0(k), \cdots, x_0(m)); k = 1,2,3,..., m \tag{1}$$

$$\left.\begin{array}{l} x_{1=(x_1(1), x_1(2), \cdots, x_1(k), \cdots, x_1(m))} \\ x_2 = (x_2(1), x_2(2), \cdots, x_2(k), \cdots, x_2(m)) \\ \vdots \\ x_i = (x_i(1), x_i(2), \cdots, x_i(k), \cdots, x_i(m)) \\ \vdots \\ x_n = (x_n(1), x_n(2), \cdots, x_n(k), \cdots, x_n(m)) \quad i = 1,2,\ldots,n \end{array}\right\} \tag{2}$$

1. GRA generation: $x_i^*(k) = \dfrac{x_i(k) - \min\limits_i x_i(k)}{\max\limits_i x_i(k) - \min\limits_i x_i(k)}$ (3)

where $\max\limits_i x_i(k)$ means the maximum number in j and $\min\limits_i x_i(k)$ means the minimum number in j .

2. GRA Calculation: $\Gamma_{0i} = \Gamma(x_o(k), x_i(k)) = \dfrac{\overline{\Delta}_{\max} - \overline{\Delta}_{0i}}{\overline{\Delta}_{\max} - \overline{\Delta}_{\min}}$ (4)

where $\overline{\Delta}_{0i} = \left\| x_{0i} \right\|_\rho = (\sum_{k=1}^{n} [\Delta_{0i}(k)]^\rho)^{\frac{1}{\rho}}$

3. Make Γ denote a grey relational matrix, which is the result of a globalized GRA.

$$\Gamma = \begin{bmatrix} \gamma_{11} & \gamma_{12} & \cdots & \gamma_{1m} \\ \gamma_{21} & \gamma_{22} & \cdots & \gamma_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ \gamma_{m1} & \gamma_{m2} & \cdots & \gamma_{mm} \end{bmatrix} \tag{5}$$

where $i, j = 1,2,...m$;

$$y_{ij} = 1 - \frac{\left\| x_i - x_j \right\|_\zeta}{\max \forall_i \max \forall_j \left\| x_i - x_j \right\|_\zeta} \tag{6}$$

2.2. Grey Student-Problem Chart Theory

The original S-P chart analysis method (student-problem chart) was first introduced by Takahiro Sato [5]. The main purpose of it is to obtain the students' response patterns and provide teachers with the idea of improving the teaching methods and offering efficient remedial courses based on Bloom's learning evaluation [7,16]. However, in order to reach more specific data analysis, Nagai Masatake proposed the GSP chart which combines GRA and S-P chart [8]. With the GSP, it is possible to make the analysis more concrete and accurate, and the uncertain factors in the studies can also be analyzed. The weight or ordinal

numbers between the discrete data can be evaluated in the GSP by using Nagai's equations. To sum up, the GSP is an effective way to deal with complicated factors and cause-effect research [3,8].

Besides, Rasch model, which is one of the psychometric models creating by Rasch, is also included in the GSP to create measures [3,17~19]. It represents the item difficulty parameter, and the three-parameter logistic model is shown as follows:

$$\Pr(X_i = 1|\theta) = c_i + \frac{1 - c_i}{1 + \exp[-1.7a_i(\theta - b_i)]} \tag{7}$$

where θ means test-takers' abilities; a_i means item discrimination parameter; b_i means item difficulty parameter; c_i means item guessing parameter and $\Pr(X_i = 1|\theta)$ means probability of a test-taker (ability= θ) answering this item correctly. The item difficulty parameter, points on the theta continuum, corresponds to a 50% probability of endorsing the item [3,18~19].

3. Research Design

3.1. Participants

The participants of the paper are thirty-eight daytime freshman students and thirty-seven extension students in a private university in central Taiwan, and all of them are not English majors. However, the students in daytime class are full-time students, but the extension students need to work during the daytime and then come to school in the evening.

3.2. Establishing the GSP chart

The participants were asked to take the same English reading exam with forty questions. The reliability coefficient of the exam results was examined using Cronbach's Alpha and the results are shown in Table 1.

Table 1 Reliability of the raw data

Freshman Class	Cronbach's Alpha
Day-time	$\alpha = 0.815$
Extension	$\alpha = 0.807$

Based on the results, the S-P chart is established by coding the raw data of each class in either 0 or 1 (0 means incorrect; 1 means correct). Next, the results are analyzed by using Nagai's equation and Matlab 7.0 [12~14]. The equations of LGRA and Larger-the-better are used to calculate *Gamma* values which can help generate GSP charts of both classes as shown in Fig. 1.

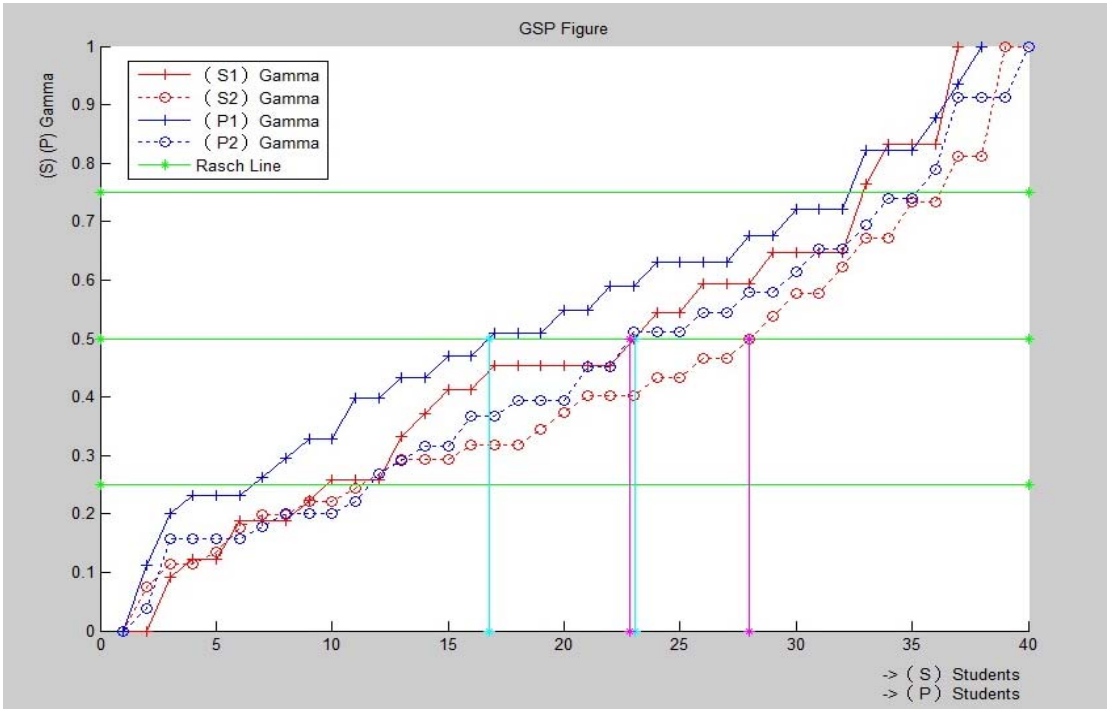

Fig. 1 GSP of daytime & extension students

3.3. Results and Discussion

The paper proposes the method of GSP to cluster students' test performances based on their English reading performances. According to *Gamma* value (Y axis) in Fig. 1, the students can be clustered into four groups as shown in Table 2 [4, 20].

Table 2 Clustered group

Group	Exam performance	*Gamma* value
A	High	$Gamma \geq 0.75$
B	Intermediate-high	$0.5 \leq Gamma \leq 0.75$
C	Intermediate	$0.25 \leq Gamma \leq 0.5$
D	Low	$Gamma \leq 0.25$

The English reading comprehension abilities of the four groups can be recognized as follows: group A means excellent English reading abilities, and the students can continue to make progress using their learning style; group B means good English reading abilities, and they just need little encouragement to push them forward; group C means students whose English reading ability is okay, and they need teachers to provide more reading exercises; group D means poor English reading abilities and the learning style needs to be checked. Teachers need to pay more attention to group C and D whose ability is lower than 0.5, and teachers have to adjust the teaching methods to the students' learning paces. Besides, the students on X axis represent the progress of learning. When time goes by, the students can learn more and make progress on their reading abilities. Moreover, the slope of daytime students is greater than extension students which can be interpreted to have more discrimination ai, and the slope also shows that the day-time students perform better than extension students in the reading exam.

4. Conclusions

The paper provides an innovative and systemic research method by using GRA, S-P chart, and GSP chart [3,4,18]. We also consider the sequence, continuity, articulation and integration of the research structure. Through these methods, the results are presented clearly, and they are shown in GSP figure which can be the reference for teachers to evaluate students' performances and adjust their instructional approaches to meet the students' individual need. Besides, the slope in the GSP chart (Fig. 1) shows the different performances between day-time and extension students in a quantitative way. Moreover, the clustered information can be served as guidelines for teachers as well as students to improve the pedagogies and provide remedial courses [3, 12~14].

The contributions of the paper can be concluded as follows:

- According to the GSP chart, students can be clustered and teachers can adjust their teaching to different groups.
- The slope of the lines show that day-time students performed better than extension students.
- Based on Rasch model, the *Gamma* line is presented clearly in the middle of the GSP chart, and students' abilities can be judged.

To sum up, the GSP chart is the new clustering method in educational evaluation field, and some practical problems with the application of them had been applied in many domains. A limitation of this paper is that there is only one example of English reading exam performances to verify the clustering, but this is our main contribution in the paper.

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