

The Investigation of S-P Chart Analysis on the Test Evaluations of Equality Axiom Concepts for Sixth Graders

YUAN-HORNG LIN
 Department of Mathematics Education
 National Taichung University
 140 Min-Shen Rd., Taichung City 403, Taiwan
 Taiwan

SHAU-MING CHEN
 Graduate School of Educational Measurement and Statistics
 National Taichung University
 140 Min-Shen Rd., Taichung City 403, Taiwan
 Taiwan

Abstract: The purpose of the study is to explore the feasibility of using S-P chart analysis on the item analysis for test of equality axiom. The S-P chart analysis could provide the two caution indices. One is the caution index for students (CS) and the other is the caution index for problems (CP). With these two indices, we could select items with proper qualities and understand the cognition and learning condition of students. The study shows that the usage of S-P chart analysis is a feasible and effective way for assessment analysis. Finally, based the findings of this study, some suggestions and recommendations are discussed.

Key-Words: caution index for problems, caution index for students, cognition diagnosis, equality axiom, S-P chart.

1 Motivation and Introduction

One benefit of educational measurement is to realize the learning condition of students. However, the quality of items, such as discrimination and difficulty, is necessary so that the test scores could reveal the learning achievement of students [12]. In the viewpoints of classical test theory, the total scores of students in assessment are considered as the learning achievement [1]. However, the task-takers may own different cognition structures even though they have the same total scores. However, response patterns of students could provide important information about items and task-takers [3] [10] [11].

Based on the response patterns of task-takers, [2] provided the method of S-P chart analysis. The S-P chart analysis is also an theory foundation of the Rule Space, a well-known cognition diagnosis model [5] [6].

In the study, the S-P chart analysis will be used to analyze the testing data of equality axiom concepts for sixth graders. The information of two indices, caution index for students and caution index for problems, will be discussed so that the selection of items and cognition diagnosis for students could be properly decided [9].

2 Overview on S-P Chart Analysis

S-P chart analysis could generate two indices for

items and task-takers separately. Besides, the S-P curve will be also generated so that the disparity between ideal response pattern (Guttman scale) and empirical data will be clearly displayed [7]. For the data matrix of dichotomous scoring, it is assumed that there are N ($i = 1, 2, \dots, N$) task-takers and M ($j = 1, 2, \dots, M$) items. Let $Y = (y_{ij})_{N \times M}$ displays the data matrix. For task-takers, it is defined that $y_{i\bullet} = \sum_{j=1}^M y_{ij}$ and $y_{1\bullet} \geq y_{2\bullet} \geq \dots \geq y_{N\bullet}$. after proper sorting technique is applied. In the same way, it is defined that $y_{\bullet j} = \sum_{i=1}^N y_{ij}$ and $y_{\bullet 1} \geq y_{\bullet 2} \geq \dots \geq y_{\bullet M}$.

According to the data matrix, the caution index for student i (CS_i) is defined as follows [4] [8].

$$CS_i = 1 - \frac{\sum_{j=1}^M (y_{ij})(y_{\bullet j}) - (y_{i\bullet})(u')}{\sum_{j=1}^{y_{i\bullet}} y_{\bullet j} - (y_{i\bullet})(u')} \quad (1)$$

where $u' = \frac{1}{M} \sum_{j=1}^M y_{\bullet j}$

The caution index for item j (CP_j) is defined as follows [4] [8].

$$CP_j = 1 - \frac{\sum_{i=1}^N (y_{ij})(y_{i\bullet}) - (y_{\bullet j})(u)}{\sum_{i=1}^{y_{\bullet j}} y_{i\bullet} - (y_{\bullet j})(u)} \quad (2)$$

where $u = \frac{1}{N} \sum_{i=1}^N y_{i\bullet}$.

The higher CS_i means that there is unusual or aberrant response pattern for student i . Similarly, the higher CP_j also means that there is unusual response pattern for item j .

3 Research Design

The software used for S-P chart analysis is implemented by the authors. This software processes data matrix under the Windows XP personal computer system.

Concepts of equality axiom are the basis of algebra. With the help of S-P chart analysis, the assessment in this study will be evaluated properly. There are 28 items in the equality axiom test. All these items are dichotomous. The sample includes 465 sixth graders in Taiwan.

Based on the two dimension, caution index for problems and correct ratio of task-takers, all items could be classified into four type, which are A, A', B, B'. It is depicted in Figure 1.

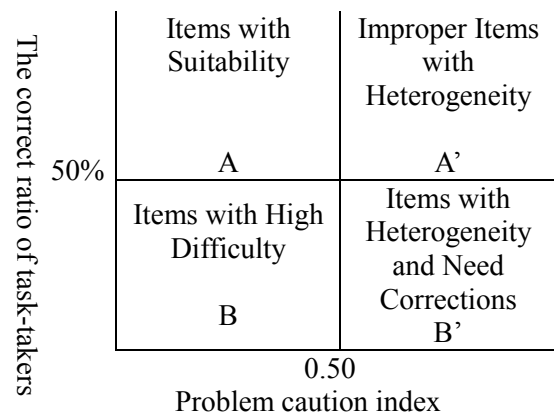


Fig. 1. Classifications of Items

Similarly, based on the two dimension, caution index for students and correct ratio on items, all task-takers could be classified into six types, which are A, A', B, B', C, C'. It is depicted in Figure 2.

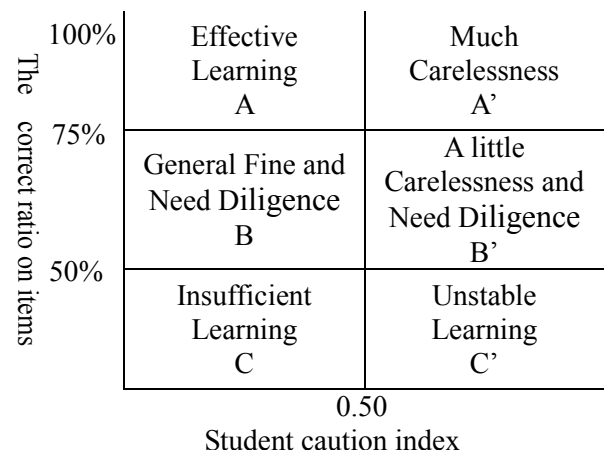


Fig. 2. Classifications of Task-takers

4 Results

Results of classifications on items and students will be discussed as follows.

4.1 Evaluations on Items

According to the classification method of items, the results are depicted in Table 1. The number of items which belong to A , A', B, B' are 18,1, 6, 3 respectively. The items of type A' and B' need advanced corrections.

Table 1. Results of Items Evaluation

Item ID	correct ratio	CP	Item Types
8	91.61%	0.28	A
4	90.96%	0.46	A
10	89.24%	0.31	A
13	88.60%	0.41	A
27	87.74%	0.33	A
12	80.64%	0.4	A
5	78.49%	0.41	A
6	75.69%	0.40	A
28	75.48%	0.42	A
17	67.95%	0.42	A
20	67.09%	0.30	A
21	66.66%	0.45	A
18	64.73%	0.40	A
2	64.51%	0.44	A
24	63.44%	0.22	A
16	63.22%	0.37	A
22	63.22%	0.21	A
23	62.58%	0.16	A
1	80.86%	0.50	A'
15	57.84%	0.39	B
19	46.02%	0.42	B
3	39.78%	0.44	B
7	36.98%	0.49	B
26	11.82%	0.21	B
25	11.39%	0.20	B
14	50.96%	0.66	B'
11	39.35%	0.52	B'
9	33.33%	0.56	B'

4.2 Evaluations on Students

According to the classification method of task-takers, the results are also depicted in Table 2. The number of students belonging to each type is depicted in Table 2. Those students who belong to A', B', C' and C should need more remedial instruction and guidance in learning concepts of equality axiom

Table 2. Results of Students Evaluation

Students Types	Frequencies
A	112
B	154
C	88
A'	41
B'	36
C'	34

5 Conclusions

The S-P chart analysis provides an alternative way to evaluate the qualities of items and learning conditions of task-takers. This methodology is suitable for empirical education environment. However, the S-P chart analysis is limited to dichotomous items. Future research could focus on the issues of S-P chart analysis for polytomous items and apply it to another educational data.

References:

- [1] L. Crocker, and J. Algina, *Introduction to classical and modern test theory*, 1986, Holt, Rinehart and Winston.
- [2] T. Sato, The S-P chart and the caution index, *NEC Educational Information Bulletin*, Vol. 80-1, 1980.
- [3] P. D. Nichols, S. F. Chipman, and R. L. Brennan, *Cognitively Diagnostic Assessment*, Lawrence Erlbaum Associates, 1995.
- [4] T. Sato, and M. Kurata, Basic S-P score table characteristics, *NEC Research and Development*, Vol. 47, 1977, pp.64-71.
- [5] K. K. Tatsuoka, Rule space: An approach for dealing with misconception based on item response theory, *Journal of Education Measurement*, Vol. 20, 1983, pp. 345-354.
- [6] K. K. Tatsuoka, Caution indices based on item response theory, *Psychometrika*, Vol. 49, 1984, pp. 95-110.

- [7] I. Chacko, S-P chart and instructional decisions in the classroom, *International Journal of Mathematical Education in Science and Technology*, Vol. 29, 1998, pp. 445-450.
- [8] T. E. Dinero, and S. L. Blixt, Information about tests from Sato's S-P chart, *College Teaching*, Vol. 36, 1988, pp. 123-128.
- [9] H. Y. Wu, Software based on S-P chart analysis and its application, *Proceedings of the National Science Council*, Vol. 8, 1999, pp. 102-107.
- [10] D. M. Switzer, and Connell, M. L. Practical applications of student response analysis, *Educational Measurement: Issue and Practice*, Vol. 9, 1990, pp. 15-17.
- [11] M. D. Miller, Time allocation and patterns of item response, *Journal of Educational Measurement*, Vol. 23, 1986, pp.147-156.
- [12] A. S. Mcdonald, The impact of individual differences on the equivalence of computer-based and paper-and-pebcil educational assessments. *Computers and Education*, Vol. 39, 2002, pp. 299-312.