Chen, W. et al. (Eds.) (2017). Proceedings of the 25th International Conference on Computers in Education. New Zealand: Asia-Pacific Society for Computers in Education

Evaluation of Mathematics Knowledge Level through Personalized Learning Exercise based on the Adaptive Tests

Yan LIU, Chuxin FU & Xiaoqing GU*
East China Normal University, Department of Educational Technology, Shanghai,China
* xqgu@ses.ecnu.edu.cn

Abstract: Personalized exercise pursues the goal of the most effective improvement by least exercise. How to recommend exercises for students to achieve this goal is the core and key issues of personalized exercise. This paper analyzed the feasibility of applying adaptive testing in personalized exercise, and adopted non-equivalent control group pre-test post-test designing. The result has shown that applying adaptive test can effectively improve the students' ability level and performance.

Keywords: personalized learning exercise, Adaptive Testing, IRT, Feedback Theory

1. Introduction

There were so much homework for students, which probably make repeat exercise in vain in current K-12 schools. According to knowledge gained level, it is necessary to acquire students' skills to organize personalized learning exercise. Lord's (1980) theory was applied that if a question, which was neither difficult nor easy for the students, would be a good question. In other words, the core of personalized learning exercise is finding out appropriate questions.

Item Response Theory (IRT) (Edelen & Reeve, 2007) was a new measure theory breaking through classic measure theory limitations, firstly known as the potential trait theory. The most important feature of IRT compared with classic theory is the invariance of both item parameters and ability parameters, and two parameters are placed in the same scale. Learning Feedback was proposed for the first time in 1948 by the founder of cybernetics (Wiener, 2000). In the field of education, feedback can help learners to modify their own ideas and behaviors to promote learning (Bangert, et al., 1992). Moreover, it also can help teachers to adjust teaching plan to adapt to each levels of learners (Shute, 2008).

2. Methodology

2.1 Participants

The study selected 44 students from two Grade 8 classes taught by the same math teacher in a Shanghai Junior Middle School. They were divided by the experimental group, and the control group, the experimental group was adopted adaptive test.

2.2 Hypotheses

The first hypothesis was that the average increase in the number of students using the individual exercises would be better than the student using the general exercise. The second hypothesis was considered that the average increase of tests using personalized exercises would be higher than the average increase in scores for tests using general exercises.

2.3 IRT Algorithm

This study mainly discussed logistic model of 0-1 scoring single-dimensional IRT model using three-parameter Logistic model (3PLM)(Birnbaum,1968), the formula is as follows:

$$P_i(\theta) = c_i + \frac{1 - c_i}{1 + e^{-Da_i(\theta - b_i)}}$$

i is the i-th item; D is a constant,1.7; a_i is the degree of discrimination for the i-th item; b_i is the difficulty of the i-th item; c_i is the guess coefficient of the i-th item; θ *is* students' b ability level estimated according to test performance.

2.4 Experiment Processing

First, we used R to calculate theta and create items. Second, the study has assigned learning exercise tasks as shown in Figure 1, the experimental group was adopted adaptive test while control group did not.

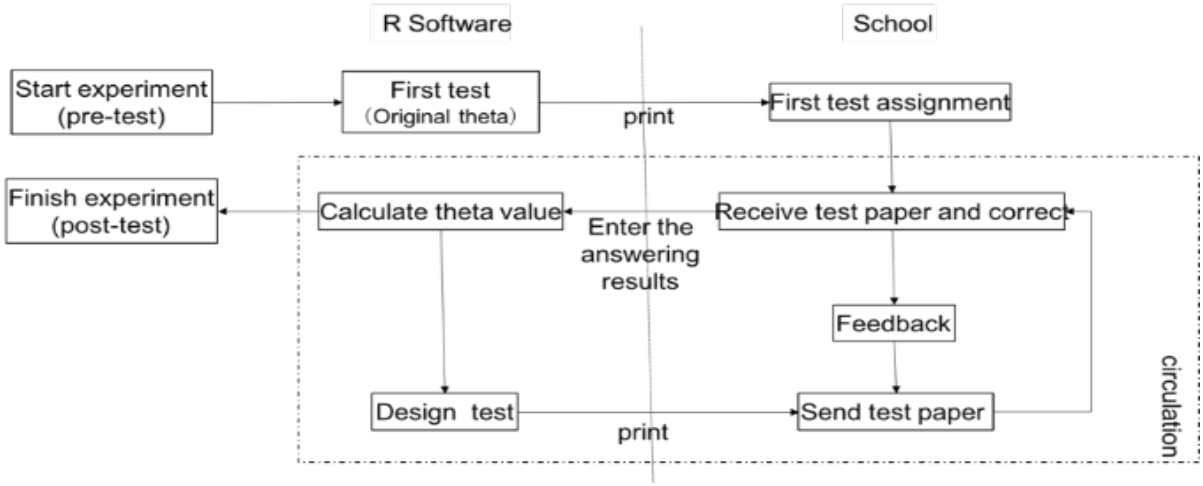

Figure 1. Experiment process

3. Results and Discussion

There were four exercises conducted for two groups. After each exercises completing, theta values were estimated based on the students' answering results, respectively recorded as theta 1, theta 2, theta 3, and theta 4. The initial theta value was recorded as theta 0. Firstly, the study was used ggplot2 package of R language to draw theta value of the probability density function diagrams (Figure 2), and theta value distribution was similar with the normal distribution.

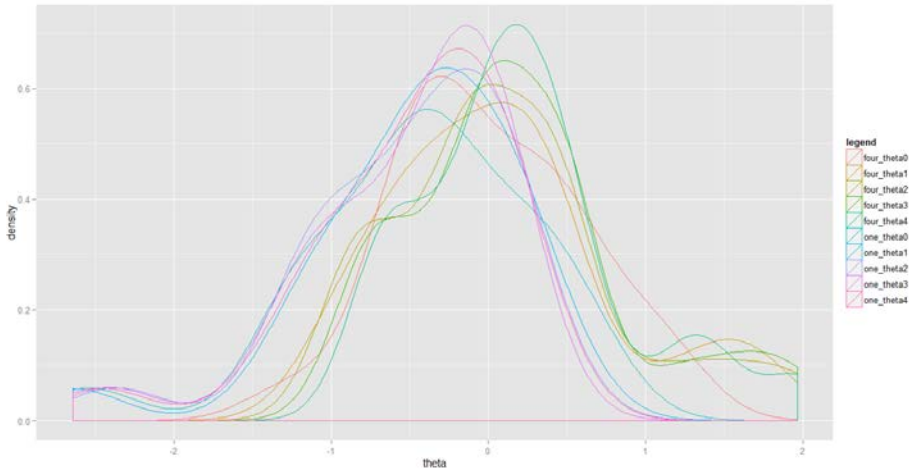

Figure 2. Theta value probability density distribution between two groups

First, mean of θ of the Experiment group has changed, however, change of means among Control group was not obvious; the standard deviation of the Experiment group and the Control group varied a little. The minimum value of θ of the Experiment group has improved quite a lot (theta0=-1.238, theta4=-0.745), however, the control group was not obvious (theta0=-2.540, theta4=-2.466).

3.2 *Overall Change of Students' Achievement*

In order to verify the effect of practice intervention on student achievement, teacher sent the previous unit test (pre-test), which were with equivalent difficulty. Independent sample T test was conducted to exam the pre-test between experimental and control group. The result indicated that the variance of the two groups before the test results are missing ($F = 7.957$, $p < 0.05$) in the Table 1, which has been to deny the variance equivalent hypothesis. The result of variances, which were not equal ($t = -3.806$, $p < 0.05$), have showed that pre-test scores was significantly different in different groups. The results showed that personalized learning exercise can effectively improve the student's theta value and scores.

Table 1 Independent sample t-test results of pre-test scores

		Levene test of variance equation		The t-test of mean equation		
		F	Sig.	t	df	Sig.(two sided)
Pre-test	variance are equal	7.957	.007	-3.806	42	.000
	variance are not equal			-3.806	35.554	.001

4. Conclusion and Limitations

The concept of personalized learning exercise has been defined that we would apply personalized feedback to student by adaptive test to diagnose each test results. The personalized training recommended mechanism to achieve the goal is the key to solve problems. The results showed that: (1) In general, when the amount of items is not handful, random exercises has been no significant effect on students' ability level. (2) In terms of student outcomes, the individualized learning exercise has been improved the value of theta and scores in each test. In the future research, the number of participant should be increased. The future study will consider various impacts, such as learning strategies, to modify the adaptive test arithmetic.

References

Bangert-Drowns, R. L., Kulik, C. L. C., Kulik, J. A., & Morgan, M. T. (1991). The instructional effect of feedback in test-like events. *Review of Educational Research*, 61(2), 213-238.

Birnbaum, A. (1968). Some latent train models and their use in inferring an examinee's ability. *Statistical Theories of Mental Test Scores*, 395-479.

Edelen, M. O., & Reeve, B. B. (2007). Applying item response theory (IRT) modeling to questionnaire development, evaluation, and refinement. *Quality of Life Research*, 16(1), 5.

Lord, F. M. (1980). Applications of item response theory to practical testing problems. Routledge.

Shute, V. J. (2008). Focus on formative feedback. *Review of educational research*, 78(1), 153-189.

Wiener, N. (2000). Cybernetics: or control and communication in animal and the machine, 11(2), 145-147.