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An Experimental Research on the Transfer of Mathematics Skills Based On Self-Monitoring Strategy

Lianhua Ning
Nanjing Normal University, China
Zi Sun
Zhejiang Jinhua No.1 High School, China

This research investigated the different influences of skill transferring in mathematics, which was produced through the strategy of excessive with similar examples and monitoring oneself from the preparation work to implementation and subsequent investigation. The methods used for evaluation data included an IQ test, a targeted transferring test, formative assessment, summative assessment, an objective interview, and individual tracking observation. The results showed that the strategy of monitoring oneself was better than excessive exercise with similar examples in enhancing the transferring of skill.

Key words*:* self-monitoring, generating migration theory, skill transferring.

Introduction

The development of mathematics skills is one of the core targets of high quality mathematics education (Grouws, 1999). How to effectively promote the transferring of mathematical skills is the focus of mathematics teaching. Chinese traditional mathematics teaching pays attention to “Sample analogy - Strengthening exercises”, and the students’ mathematical transfer skills were developed through these paradigms (Ren, 1998). The theoretical basis of this operating mode was based on the “Generating transfer theory” created by Singley and Anderson (1989). Singley and Anderson (1989) believe that the two learning skills, one after another, produces transfer as the two skills have an overlapping “production system”, and the more overlap, the more transfer. Based on this assumption, teaching with an emphasis of practice based on the similarity of examples and using the analogy method are very important in skill transfer (Shan, 2005).

The significance of Anderson's theory in mathematics teaching practice is that the skill transfer theory based on the general sense extrapolates to the particular subject of mathematics learning. Singley and Anderson's (1989) theory has two different perspectives: First, the empirical research "Generating transfer theory" mainly comes from the materials of the computer programming language learning, and the study of these materials was involved more with conventional operation, which has limited connections with complex cognitive operating activities. However, the transfer of mathematics skills always requires complex cognitive operating activities. Second, mathematics activities are based on rational thinking, which rely on the students' active participation. However, in the "strengthening exercises based on the similarity of analogy" in nearly half of the mechanization imitation operation, students do not implement effective monitoring and regulation for their cognitive process.

The current experiment hypothesis is that when we present problems to students in teaching, we could make them focus more on what they are doing and thinking, when they analyze problems, instead of the problem itself. This way we could make students monitor and regulate their behavior all the time, which may have the same effect without engaging them lots of strengthening exercises, thereby obtaining the effect of skill migration even more than implementing "strengthening exercises based on the similarity of analogy". The current experimental research has abandoned the customary practice in Pedagogic Psychology research that allows the testee to concentrate on short-term training and testing, and then makes quantitative and qualitative analysis. Instead, we tried to use the favorable conditions encountered when researcher as an instructor: we set up experiment and control classes and observed our own teaching practice for three years.

Method

Time and Methods

This experimental study lasted for nearly three years from the preparation work to the implementation and subsequent investigation. The methods used for data evaluation included an IQ test, a targeted transfer test, formative assessment, summative assessment, the objective interview, and individual tracking observation.

Participants

Two parallel classes from 7th grade in one middle school with 103 students were involved in the current study (52 students in class one, 51 students in class two). Class one was the experimental class, class two was the control class. We took the scores of the unified test as the reference index of skills transfer effect. According to the IQ test and the scores of the entrance examination in seventh grade and phase examination in grade 7, 8 and 9. We choose 60 students as the object of comparative classification skills transfer. These students whose academic record are relatively stable, which include 10 high achieving students (HAS), 10 middle achieving students (MAS) and 10 low achieving students (LAS). In order not to cause students in the experimental group to appear to suffer from “Hawthorne effect”, all the students stayed in their own classes and they didn’t know that they were participating in an experiment.

Procedure

We used different teaching methods for the experimental class and the control class, guiding students to use different learning strategies in order to achieve math skills transfer. We use the traditional mathematics teaching method to guide the students in the control class, in other words, based on the “Generating transfer theory”, we took the conventional method that states “sample analogy - strengthening exercise”, which had a belief in “Practice makes perfect”.

Training students’ self-monitoring ability was the purpose of teaching, and design of the control class students in teaching, and designing the corresponding methods for teaching and guiding control class students. We guided the students actively in the process of solving problems using self-monitoring strategy, repeatedly asking the students the following questions: 1) what are you doing? (Can you talk it definitely?); 2) Why did you do like this? (Can you explain it?); 3) did you have any help to do it like this? (What did you do after you got the answer?). In addition, we let the students ask questions of each other and exchange their experiences frequently, but provided little or no practice. We made students gradually understand: please show your process rather than the results.

The first strategy makes students learn through "understanding what it is". The second strategy makes the students be concerned with the cognitive activity itself and to learn "understand why it is". The proportion of problems for the two different strategies is about 3:1.

Instruments

The students in the control class and the experimental class took the same test. The scores of the test were the dependent variable. We also used the interview to understand the students′ thinking activity during the process of problem solving.

(1)We took the eight times formative evaluation scores of grade 7, grade 8, grade 9 and the graduation examination scores of grade 9 as the auxiliary dependent variable of the transfer test to investigate. (2) We design four tests to inspect the skill transfer of the students, the testing time and content respectively: 1) in grade 7 - Polynomial Multiplication; 2) in grade 8 - Factorization; 3) in grade 8 - the proof of similar triangles; 4) in grade 9 - the solution of quadratic equation.

Each test design was of three types: 1) the same type problem; 2) a near transfer problem of high similarity; 3) a far transfer problem of low similarity. The analogy with the present sample and the proportion was 1 : 2 : 1. The results of the experiment were a significant analysis with independent sample by *Z* test.

Data Analysis and Results

The Analysis of Unified Test

We took the unified test's results of the experimental class and the control class as a reference to analyze the effect of the transfer (Zhang & Guo, 2004). In eight unified tests, the scores of the control class were higher than the experimental class in the first and second test. However, the scores of the experimental class were higher than the control class in the last six tests, and presented a stronger trend, especially in the graduation examination showing the greater between the two classes. The results shows that student go through an adaptive processes to learn the new strategies. At first, the students do not adapt to the self-monitoring strategy and do not want to give up the familiar conventional practices that also results "sample analogy - strengthening exercise". They look as if not know what to do.

The results from analysis indicate that the self-monitoring strategy has statistically significant positive effects on improving math scores. The comparative analysis of the two scores in succession is listed in table 1.

Table 1

Comparison Table about the Two Scores in Succession for Subjects

	Math entrance examination of Grade 7			Math graduation examination of grade 10		
	X	*SD*	CV	X	*SD*	*CV*
Experimental class	93.2	10.8	11.2	102.6	14.9	14.5
Control Class	92.9	11.4	10.6	90.3	15.8	16.9
Z	1.843			3.827		
P	0.76			0.0053		

note：X - average score S - Standard deviation CV - coefficient of standard deviation

Table 1 shows that the mathematics average scores and the polarization level of the experimental class and the control class are almost the same in the pretest; however, the average score has a significant difference (12.3) in the posttest. The result of the significant test is: $Z=3.827$, $p<0.01$, which shows that the average scores of the experimental and the control class on the test have significant differences. The score of the experimental class is significantly higher than the control class. The self-monitoring strategy has some relationship with the transfer of skill, and it could obviously reference influence the whole performance in mathematics.

Skill Transfer

From the results of four targeted transfer tests given to the experimental class and the control class, we found that the scores of the experimental class are lower than the control class in the first test. However, on all the following tests, the scores of the experimental class are higher than the control class. The result has strong consistency with the contrast results of the unified test between the control class and the experimental class (see table 2).

Table 2

Comparison Table about the Results of Skills Transfer for Two Groups Subjects

	Control Class		Experimental class		Significance Test	
	X	*SD*	*X*	*SD*	*Z*	*P*
HAS	93.4	14.41	85.9	15.53	3.12	<0.01
MAS	83.5	11.21	78.2	11.30	2.87	<0.05
LAS	74.6	7.72	67.7	8.11	3.07	<0.01

Table 2 shows that skills transfer presents significant differences between the control group and the experimental group. The secondary group presents significant differences at the level of $p< 0.05$. Both the higher group and lower group present significant differences at the level of $p< 0.01$. It shows that after a long time of training, the students' self-monitoring ability has reached a higher level, and it resulted in significant positive effects on the transfer of math skills.

Comparisons of the Differences in Scores among the Three Transfer Tests

According to the characteristics of the design skill transfer tests, we designed three kinds problem each with a different difficulty level. They are 1) the same type of problem; 2) the near transfer problem; and 3) the far transfer problem. The table below is the score of each type of problem in the fourth skills transfer tests (Table 3).

Table 3

Results about the average scores of the three kinds transfer tests

	Experimental class			Control class			*P*
	HAS	MAS	LAS	HAS	MAS	LAS	
same type	20.0	19.4	18.8	20.0	19.1	18.9	>0.05
near transfer	58.2	52.3	48.5	53.1	50.4	45.2	<0.01
far transfer	15.2	10.8	7.3	12.8	9.0	4.0	<0.01

The results from the statistical analysis indicate that the average scores between groups don′t have an obvious difference (P>0.05) in the same type problems; however, the average scores of lower students in the control class are better than the students in the experimental class. It shows that, if we do not consider the efficiency, practice could promote the transfer of basic s mathematics skills. Differences in scores are the result of the scores of the near transfer and far transfer tests; the two cases present significant differences ($p<0.01$). Thus, for the transfer of more complex mathematical skills, the self-monitoring strategies effect is more apparent.

The results show that Andersons′ “Generating transfer theory” takes effect only in the initial stage of problem solving. As for the transfer problems which have slight variation, the method of doing lots of strengthening exercises is obviously inadvisable. On the contrary, the effects of using the self-monitoring strategy are not less than doing lots of strengthening exercises. Its advantages are more in an increase in the ability of solving the variation problems. Because reflected the self-monitoring strategy is a kind of constructive activity, it gives full play to the initiative of students and reflects the students' major role. It is also propitious to induce students’ learning motivation. Through monitoring and regulating their own cognitive behavior, a clear relevant schema can take shape in their mind; it will be sure to promote the transfer of math skills effectively.

Conclusion

Experimental results show that (1) the effect of monitoring and the adjustment of cognitive activities can make a substantial connection between new and old knowledge, and it plays a significant role in promoting the transfer of mathematics skills. In contrast, the strengthening practice strategy based on similarity only concerns the problem itself, and the concatenations which the students establish in this mind are just the surface characteristics of the new knowledge, thus the scope of math skills transfer is not as wide as the former; (2) the skills transfer of solving non-routine problems depends on the enhancement of students' self-monitoring ability, and lots of strengthening practice is not enough.

The self-monitoring strategy could achieve maximum results with little effort for promoting the mathematical skills’ transfer. Several mathematics educators provided their explanations of this theory. For example, Polya (2007) emphasis on solving reflection in *how to solve it - a new aspect of mathematical method*, and solving reflection is the self-monitoring strategy in mathematics learning. Freudenthal (1999) also emphasize that “we should let the student study mathematicization; rather than learn mathematics. The process of mathematicization contains the meaning of "teach how to fish"; it has the same meaning cultivating students' self-monitoring ability.

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Author:

Lianhua Ning
Nanjing Normal University, China
Email:ninglh@126.com

Zi Sun
Zhejiang Jinhua No.1 High School, China
Email：jinhuayizhongsunzi@126.com