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ABSTRACT

Transfer of learning is one of the major purposes of education. Theories and research have tried hard to answer questions such as: how does transfer occur? and how is transfer enhanced? Situated cognitive theory and research about anchored instruction together bring some positive findings. Anchored instruction provides the learner with a situated, authentic, and social learning environment, and students learn to solve problems rather than learning facts or principles. Although students are able to solve various problems in this rich context, whether they can solve problems successfully in a novel context remains to be determined. This study investigates how different knowledge abstraction strategies affect students' transfer ability. The teaching of problem-solving strategies in anchored instruction was hypothesized to help students abstract knowledge from context. An experiment was conducted with 72 Taiwanese fifth graders to compare how three different knowledge abstraction strategies affect near- and far-transfer: (1) teaching problem-solving strategies; (2) practicing various problems with self-reflection activity; and (3) no knowledge abstraction activity (control group). Results indicate that all three groups performed better on solving far-transfer problems than on solving near-transfer problems. Possible reasons for this abnormal result are discussed. Group differences were not statistically significant. Comparing group performance finds: the self-reflection group outperformed the other two groups on far-transfer and overall transfer tests; the control group did the best on near-transfer, and performed worst on far-transfer; and the problem-solving strategies group performed worse than the other two groups in overall learning transfer. (Contains 23 references.) (Author/SWC)

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Effects of Knowledge Abstraction with Anchored Instruction on Learning Transfer

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Abstract

Transfer of learning is one of the major purpose of education. Theories and research have tried hard to answer questions like: How is transfer occurred? How is transfer enhanced? Situated cognitive theory and research about Anchored Instruction together bring some positive findings. Anchored Instruction provides learner a situated, authentic, and social learning environment, and students learn to solve problems instead of facts and principles. Although students are able to solve various problems in this rich context, whether they could solve problems successfully in novel context remain further studied. Would it be like procedural or skill training that is successful in simulated training context? Trainees usually could solve similar problems in real context that training context simulated (near transfer), but not on far transfer problems. It is suggested that "knowledge abstraction" is the key process for transfer to occur, and how is knowledge abstracted from context affects transfer.

This study is to investigate how different knowledge abstraction strategies affect students' transfer ability. The teach of problem-solving strategies in Anchored Instruction is considered as helping students abstract knowledge from context and is hypothesized thus enable them to transfer. Furthermore, will it be better to provide aids (self-reflection activity) for students to abstract knowledge by themselves? An experiment was conducted to compare how Anchored Instruction with (1). Teaching problem-solving strategies, (2).Practice various problems with self-reflection activity, (3). No knowledge abstraction activity, effect near and far transfer. The result indicated that all the three groups performed significantly better on solving near-transfer problems than on far-transfer. The self-reflection group outperformed the other two groups on far transfer. The control group did best on near- but worst on far-transfer. However, the group differences were not statistically significant.

Background

Transfer of learning is one of the major purpose of education. Living in this rapid-changing information society, ability of problem-solving and learning transfer is essential. Theories and research (Anderson, 1987; Cormier & Hagman, 1987) have tried hard to answer questions like: "How is learning transfer occurred?" and "How to enhance learning transfer?". Theory of Situated Cognition (Brown, Collins, & Duguid, 1989) and studies of Anchored Instruction (CTGV, 1990, 1992, 1993; Moore, et al., 1994) together bring some positive answers. Aiming to avoid inert knowledge, Anchored Instruction provides a situated, authentic, and social learning environment in which students learn together to solve problems. Previous studies of Anchored Instruction suggest positive findings on problem-solving and learning transfer (CTGV, 1992; Greeno, Smith, & Moore, 1994; Lin, 1995). However, there are two main questions about learning transfer remained further research. First, what is in Anchored Instruction that affects learning transfer? Second, how to enhance learning transfer?

In procedural or skill training, transfer is enhanced by using simulation that is similar to the real context. Trainees usually succeeded on near transfer but not on far transfer (Baldwin & Ford, 1988; Kamour, Kamouri, & Smith, 1986; Phye, 1989; Shih & Alessi, 1993). Near or far transfer refers to how similar the transfer context (setting and problem) is to the learning context. Near transfer usually refers to solving similar problems or performing learned skills in real setting that is also similar to the learning setting. Comparatively speaking, far transfer refers to solving different type of problems in settings either similar or novel to the learning setting. Theory and research of learning transfer focused on factors that affect learning transfer. These factors include:

similarities between learning and transfer contexts, use of variety of examples and practices, use of analogy, learners' prior knowledge and ability..., etc. It is agreed that there is no simple relationship between similarity of contexts and learning transfer. Furthermore, research also suggests that knowledge need to be "decontextualized" to enhance further transfer (Baldwin & Ford, 1988; Beard, 1993; Bernardo & morris, 1994; Cormier & Hagman, 1987; Grandgeneet & Thompson, 1991; Gentner & Stevens, 1983; Lin, 1995; Paas & Merrienboer, 1994; Royer, 1979; Phye, 1989; Shih & Alessi, 1993). It is argued that the critical factor for transfer to occur is learners' ability to abstract knowledge from the learning context. That is, to decontextualize knowledge from the learning context. To enhance learning transfer, especially for far transfer to occur, some process needs to happen. This process is what we call "knowledge abstraction." The notion of "knowledge abstraction" is analogical to "generalization" of cognitive skills (Anderson, 1987) or formation of "abstract schema" (Gick, & Holyoak, 1983, 1987). In short, we suggest that (1) "knowledge abstraction" is the key process for transfer to occur, and (2) how is knowledge abstracted from context would affect transfer.

Trying to help students in Taiwan to gain better problem-solving abilities, Shyu (1995) developed an interactive videodisc "Anchor's Holiday" for fifth graders to learn problem-solving on mathematics and found it enhanced problem-solving. Nevertheless, how "Anchor's holiday" help learning transfer remains further study. During previous studies (Shyu, 1995), students first watched video then tried to solve problems in the scenario with team members. After finished solving the given problem, the teacher discussed solutions with students and taught them the general problem-solving strategies that are "abstract" (not specific to any context). This teaching of the general problem-solving strategies is considered a way to help students to abstract knowledge from context, and is hypothesized thus enable transfer. Furthermore, is there a better way to help students to abstract knowledge from context by themselves? Practice solving different type of problems with self-reflection method is proposed. The self-reflection method is to write down or draw out on paper the key words, questions in mind, steps to take..., etc. during problem-solving. This serves as a reflection tool of mind, thus called "self-reflection." It is to make thoughts, ideas, plans, questions in mind concrete and thus clearer to continue and to discuss with partners. The function of self-reflection is analogical to flow-charting for programming; flow-charting provides a reflection of the program flow and algorithm and thus enable programmer to dry-run and complete or debug the program. It is hypothesized that students abstract knowledge by themselves with practicing different type of problems with self-reflection may affect their transfer ability.

The purpose of this study is to investigate the effects of "knowledge abstraction" on near transfer and far transfer. Near transfer refer to solving different problems in similar context (i.e., in Anchor's holiday scenario). In contrast, far transfer refers to solving different problems in a novel context (i.e., a written scenario that is irrelevant to Anchor's holiday). An experiment was conducted to compare how Anchored Instruction with (1). Teaching problem-solving strategies, (2). Practice solving different problems with self-reflection activity, (3). No knowledge abstraction activity, affect near and far transfer.

Research Questions

1. Does "knowledge abstraction" affect learning transfer?
2. Do different knowledge abstraction activities (teaching problem-solving strategy; practice solving different problems with self-reflection; no knowledge abstraction activity) result different effects on near and far transfer?
3. Do different knowledge abstraction activities affect near transfer?
4. Do different knowledge abstraction activities affect far transfer?

Method

A three (Knowledge Abstraction Activity: teaching problem-solving strategy; practice solving different problems with self-reflection; no knowledge abstraction activity) by two (Learning Transfer Level: near transfer; far transfer) split-plot design of experiment was conducted to answer research questions (Table 1).

Seventy-two fifth graders participated the study. Students worked together in teams. A team consisted of three students who have high, middle and low ability on math according to their previous math scores. The team members were randomly chosen from the three groups of high, middle, and low math ability. Twenty-four teams were randomly assigned to one of the three experiment groups (Group D, Group S, and Group C).

Table 1. Design of experiment

Knowledge Abstraction Activity	Learning Transfer Level	
	Near Transfer	Far Transfer
Group D teaching problem-solving strategy	NT1	FT1
Group S practice solving different problems with self-reflection	NT2	FT2
Group C no knowledge abstraction activity	NT3	FT3

The procedure of the experiment is as below:

1. Formed teams and assigned them into treatment groups.
2. Each team in each group used "Anchor's Holiday" IVD, watched video and then solved problem A.
3. For Group D.
   Each team watched solution of problem A in "Anchor's Holiday," then teacher discussed solution with students and taught problem-solving strategy.

   For Group S.
   Each team watched solution of problem A in "Anchor's Holiday," then teacher gave problem B and directed them to solve the problem with self-reflection method.

   For Group C.
   Each team watched solution of problem A in "Anchor's Holiday."
4. All the student took near-transfer test.
5. All the student took far-transfer test.

The whole procedure took seven hours to complete. It was divided into sessions on different days in one week. Test scores of near transfer (NT) and far transfer (FT) were analyzed with method of 3x2 MANOVA repeated measures. Students' solution of problem A, records of self-reflection on solving problem B, observation records during experiment, and students' previous math scores were also collected to help interpreting the results.

Results

Measures are post-test scores of near and far transfer tests: NT and FT respectively. The near transfer test asked students to solve a problem that has the same scenario to "Anchor's Holiday." However, the problem in test is about budgeting, which is different from the practiced scheduling problem. The far transfer test also asked students to solve a budget problem, but in a completely different scenario. That is, the far transfer problem is different from the learning one in terms of both scenarios and type of problem. Students were asked to write out every step they took to solve the problems. Scoring method was borrowed from protocol analysis (Williams, Hollan, & Stevens, 1983). The researchers and teachers first enumerated all the solution steps (mental process) needed to solve the problems. It took 32 steps to solve the near transfer problem, and 50 to solve the far transfer problem. These steps were used as standards to score the near and far transfer tests.

Two graders compared students' solution steps to the "standard steps" respectively. Each corresponding step scored one point. The inter-grader reliability was high, r=0.95 for near transfer and 0.91 for far transfer. The points students received from the two graders were averaged and then calculated to get percentage scores. For example, if a student received 25 points (averaged score from two graders) for near transfer, then his score (NT) is 78% (25/32*100). The far transfer score (FT) was obtained the same way. Table 1 summarizes the means and standard deviations of the near and far transfer scores (NT and FT) of the three groups.

Table 1. Means and Standard Deviations of NT and FT

		NT (Near Transfer)		FT (Far Transfer)		Learning Transfer	
Group	N	M	SD	M	SD	M	SD
Group D	24	43.55%	14.73	63.75%	24.02	53.65%	14.76
Group S	24	47.20%	26.49	67.92%	26.42	57.56%	22.68
Group C	24	50.91%	22.83	63.04%	26.01	56.98%	22.25
Overall	72	47.22%	21.81	64.90%	25.24	56.06%	20.02

To analyze data, we employed a 3 (Group: between-subjects) by 2 (Learning transfer: within-subjects) MANOVA repeated measure as statistical analysis method. The three groups: teaching (Group D), self-reflection (Group S), and the control group (Group C), belonged to the between-subject factor (Group). NT and FT are dependent variables that belonged to the within-subject factor (Learning Transfer). Table 2 reports summary of the analysis.

Table 2. Summary Table for the 3 (Group: teaching, self-reflection, control) by 2 (Learning Transfer: near, far) MANOVA

Source	SS	DF	MS	F
Between				
Group	426.37	2	213.18	0.26
$Error_{(b)}$	56465.03	69	818.33	
Within				
Learning Transfer	11253.67	1	11253.67	36.03**
Group x Learning Transfer	556.14	2	278.07	0.89
$Error_{(w)}$	21552.27	69	312.35	

** $p < .01$

Question 1 Does "knowledge abstraction" affect learning transfer?

The effects of knowledge abstraction on learning transfer were examined by comparing the learning transfer scores among the three groups, i.e. the main effect (Group) of the MANOVA analysis. Results indicated that the difference was not significant ($F_{2,69}$=.26, p >.05). Figure 1 shows the averaged learning transfer scores (near and far transfer) for the three groups. Although the three groups did not show significant difference on solving transfer problems, Group S (self-reflection) outperformed the other two groups while Group D (teaching) was inferior to the other two groups (53.65%, 57.56%, and 56.98% for Group D, S, and C respectively).

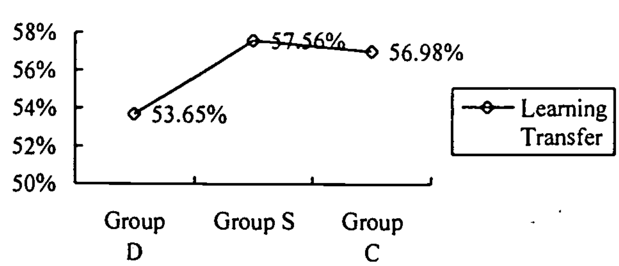

Figure 1. Learning Transfer Scores for the three Groups

Question 2 Do different knowledge abstraction activities (teaching problem-solving strategy; practice solving different problems with self-reflection; no knowledge abstraction activity) result different effects on near and far transfer?

This question could be answered by examining the Group by Learning Transfer interaction of the MANOVA analysis. Although there exists significant difference between near and far transfer ($F_{1,69}$=36.03, p<.01**) for the three groups, results did not show significant interaction ($F_{2,69}$=0.89, p>.05). The different knowledge abstraction activities did not result significant different effects on near and far learning transfer. Figure 2 shows the near transfer score (NT) and far transfer score (FT) for the three groups. Group C, the control group, did best on solving near transfer problem (43.55%, 47/20%, 50.91% for Group D, S, C respectively), but did worst on solving far transfer problem (63.75%, 67.92%, 63.04% for Group D, S, & C). Group D (teaching) did worst on solving near transfer problem and a little better than Group C on far transfer. Group S (self-reflection) was in-between the other two groups on solving near transfer problem, but outperformed the other two on far transfer.

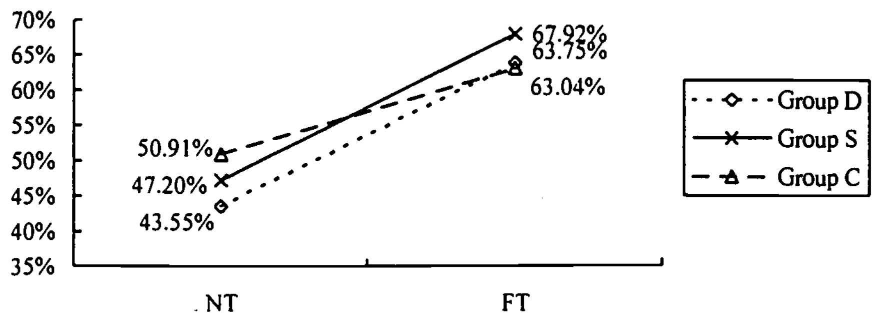

Figure 2. NT and FT for the three Groups

Question 3 Do different knowledge abstraction activities affect near transfer?

The comparisons on near transfer scores (NT) among the three groups could answer this question. The simple effect examination of NT from the 3 by 2 MANOVA showed no significant difference among groups ($F_{2,138}$=.57, p>.05). That is to say, different knowledge abstraction activities did not result significant difference on solving near transfer problem. Figure 3 shows the near transfer scores (NT) for the three groups. The control group (Group C), although did not have any knowledge abstraction activity during learning, outperformed the other two groups (43.55%, 47.20%, 50.91% for Group D, S, & C). Group D, received teaching of general problem solving strategy from teacher, did worst on solving near transfer problem. Group S, used self-reflection strategy to abstract knowledge during learning, performed worse than Group C but better than Group D on solving near transfer problem.

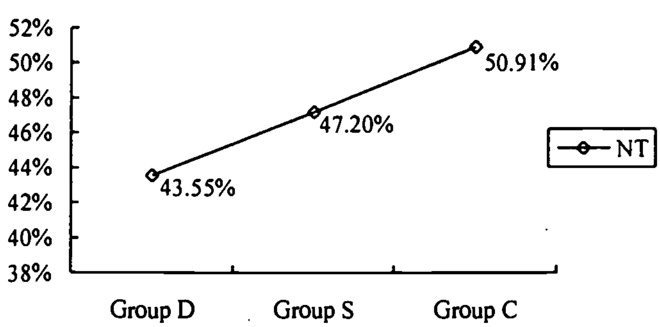

Figure 3. Near Transfer Scores (NT) for the three Groups

Question 4 Do different knowledge abstraction activities affect far transfer?

The comparisons on far transfer scores (NT) among the three groups could answer this question. The simple effect examination of FT from the 3 by 2 MANOVA showed no significant difference among groups ($F_{2,138}$=.29, p>.05). That is to say, different knowledge abstraction activities did not result sognofocant difference on solving far transfer problem. Figure 4 shows the far transfer scores (FT) for the three groups. The control group (Group C), although did best on solving near transfer problem, did worst on solving far transfer problem (63.75%, 67.92%, 63.04% for Group D, S, & C). Group D who did worst on near transfer test, performed a little better than Group C on far transfer test. Group S outperformed the other two groups on solving far transfer problem.

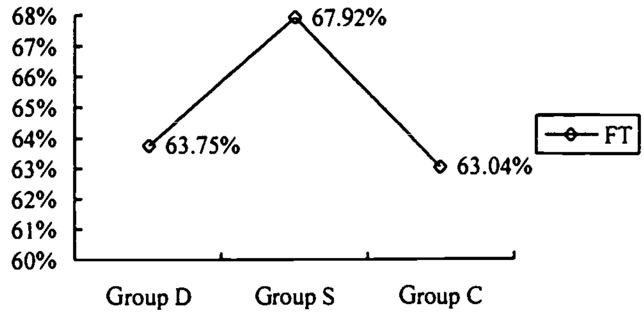

Figure 4. Far Transfer Scores (FT) for the three Groups

Discussion

Results of this study indicated that different knowledge abstraction strategies (teaching general problem-solving strategy, practice with self-reflection strategy, or no strategy) did not significantly affect learning transfer. However, results showed that each group performed significantly better on solving far transfer problem than near transfer problem. Nevertheless, different knowledge abstraction activities did not result significant difference on solving different level of transfer problems, nor on near or far transfer respectively. Although the results did not show any significant effect of knowledge abstraction strategies, there are some interesting points to discuss.

First, all students performed better on far transfer test than near transfer test. This result is quite abnormal to previous findings (Baldwin & Gord, 1988; Cormier & Hagman, 1987; Royer, 1979; Shih & Alessi, 1993). Usually, far transfer task is more difficult than near transfer task for students to perform, and students usually scored higher on near transfer test. One possible reason is that the near and far transfer tests have something in common (both asked students to solve budgeting problems). Therefore, students also "learned" on taking near transfer test and thus did better on the following far transfer test. Also, the test format is also a possible reason. On taking near transfer test, students were for the first time trying to write the test in the format. It probably took some efforts to figure out how to write the test. While on taking the far transfer test, although the problem was different, the test and the way to answer it were same as taking the near transfer test. Students could concentrate more on solving the problem and might thus do better than near transfer test.

Second, Group C did best on near transfer test and worst on far transfer test. Group C did not have any knowledge abstraction strategy during learning. That means, they learnt from the Interactive Video on their own. Since the near transfer test was budgeting questions in the same scenario as in IVD, they could use whatever solutions they obtained during learning to solve the similar problem. This might be easier to do while the other two groups were involved in "knowledge abstraction." However, when solving the far transfer problem, Group C might have not abstracted knowledge from previous learning and found it difficult to solve the far transfer problem. Therefore, they did worse than the other two groups (Figure 2). That means, the other two groups spent some effort on "knowledge abstraction" and resulted some effects on transfer, although not significantly.

Third, Group D performed worse than the other two groups in terms of learning transfer (Figure 1 and Figure 3). This result is a little surprising. Group D received teaching of general problem-solving strategy from teacher after learning from IVD. Previous studies of Anchored Instruction used this method and found positive results on students' problem-solving ability. However, in this study, compared to the other two groups, received teaching of problem-solving strategy seemed increased difficulties on solving transfer problems. Probably students had difficulties on transferring the taught problem-solving strategy to solve different problems.

Forth, the self-reflection group (Group C) increased more on far transfer scores than the other two groups (Figure 2) and did best on the far transfer test (Figure 4). This result is as predicted. Students learned from IVD by using self-reflection strategy to discuss and solve problems. Presumably, self-reflection strategy allowed students to write or draw out what they thought in mind and thus enable them to clearly identify key points, enable better communications and discussions, lay out the possible solutions and "dry-run" it, thus were more able to abstract knowledge from the context. Therefore, Group S increased their transfer ability more.

Although Group S was inferior to Group C on near transfer (Figure 3), but in far transfer and overall transfer tests, Group S outperformed the other two groups (Figure 1 & 4).

In summary, the effects of knowledge abstraction strategies on learning transfer were not statistically significant in this study. However, the results showed some effects and suggest further study on knowledge abstraction. The main possible reason that the effects were not obvious is that the experimental time (one week) was too short. It probably took longer for students to develop abstract knowledge, whether being taught or using self-reflection method. Furthermore, another interesting question would be how people abstract knowledge? Would different knowledge abstraction strategies endow different abstract knowledge? What is the knowledge abstraction process? These questions would require qualitative research method to answer.

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