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A Study of Situated Cognition and Transfer in Mathematics Learning*

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In this paper, we investigate the comparative effectiveness of two kinds of instructional methods in transfer of mathematics learning: one based on the situated cognition, i.e. situated learning (SL) and the other based on traditional learning (TL). Both classes (of grade 2) studied addition and subtraction of 3-digit numbers. After that, they completed two written tests (Written Test 1 included computation problems, Written Test 2 included computation problems and story problems) and a real situation test.
As a result, no significant differences were found between the two groups' performance on computation skill in Written Tests 1 and 2. But the SL group performed significantly better on the performance of story problem and real situation test than TL group. This result indicated that the SL made improvement in transfer of mathematics learning. As a result of interviews with 12 children of the SL group were able to use contextual resources in solving real situation as well as story problems.

1. INTRODUTION

One of the main purposes of education is to develop a student's ability to cope with various and rapidly changing world properly. Students should apply the knowledge and skills acquired in one setting to other new setting. So, our interest in the transfer is natural and rightful.

The dominating notion about transfer in this century was based on formal discipline. According to this view, transfer can occur between domains that share no contents at all.

On the other hand, by showing that transfer happened in very narrow domain, Thorndike and his followers explained the transfer through identical elements (cf. Larkin, 1989). After these studies, cognitive scientists made most of studies about transfer. They thought that mental representation was very important in cognitive development. Transfer

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depends upon representations about the initial state and the transfer state, and connection between those representations. Then the question of transfer is to understand how learners make representations from first learning and apply and connect that representation to second learning to solve the transfer problem.

But situated cognition presents a different view of transfer. In this alternative view, cognition was connected with context and learning is situated in the context in which it is constructed. That is, rather than being an entity outside of the context in which it is learned, knowledge is an integral part of the context in which it is learned (Brown, Collins & Duguid, 1989; Lave, 1988; Resnick, 1987; Greeno, 1991; Greeno, Smith & Moore, 1993). They think that cognitive changes are not made in individual mind by symbolic representations, but in the contexts by social interaction (Newman et al., 1989).

To date, the view about individual cognitive development was centered on individual's structural development. In particular this view is Piaget's notion about cognitive development. Piaget focused on individual's mental structure without considering social influences in cognitive development. But in the view of situated cognition, cognition is influenced by social contexts. In this perspective, knowledge is not an invariant property of an individual, but rather a property that is related with situations, an ability to interact with things and other people in various ways. And learning is considered to be essentially situated, an adaptation of a person or group to features of the situation in which learning occurs.

The basic proposition of situated cognition is that learning should occur through cognitive apprenticeships in which a learner completes realistic tasks under the more experienced learner. This notion suggests that learners should be paired with a more experienced learner or a mentor as they begin to learn a new task (Brown et al., 1989; Collins, Brown, & Newman, 1989). Three major principles derive from this proposition. The first principle centers on enculturation, the notion that people adopt the behaviors and belief systems of groups of people or cultures with which they interact. Secondly, Knowledge is an integral part of the context in which it is learned and of the activity in which it is developed. Lastly, authentic activity is an integral part of situated cognition. Students work with mentors and become enculturated as they engage in authentic activities. These authentic activities are coherent, meaningful, and purposeful to the practitioners of the culture in which they engage.

Then the question of transfer depends on how learning to participate in an activity in one situation can influence one's ability to participate in another activity in a different situation. The answer of that question must lie in the nature of the situations, in the way that the person learns to interact in one situation, and in the second situation that would make the activity there successful. In other words, this viewpoint is different from cognitive psychology thought that activity play important role in transfer rather than representation.

By the study of Lave (1988), children could not use mathematical knowledge studied in school in real situation, and could not connect arithmetic knowledge out of school and arithmetic knowledge in school. This means that the knowledge learned in school is inert knowledge, and then it can not be transferred into the real life out of school. The result of Saxe (1991) was similar to Lave (1988). He investigated the candy-seller children's arithmetic knowledge The candy-sellers could solve the contextualized problems better than decontextualized problems (Carraher et al., 1985).

Resnick (1987) also points out that school learning differs from outside school learning in at least four distinct ways. First, students learn through an individual process in school, as opposed to learning through the shared cognition, which usually occurs outside schools. Secondly, in school, pure thought is poured, but not in the case outside schools. Thirdly, schools emphasize symbol manipulation, whereas learners engage in contexualized reasoning in the non-school environment, that is, outside school, actions are connected with objects and events in the environment. Lastly, school learning tends to be generalized, whereas out-of-school processes are situation-specific.

The above examples lead us to question the educators' assumption that if the person learn some knowledge in school then he can transfer that knowledge in an out-of-school situation. Particularly, this question is derived from the assumption that the learners are passive receivers of wisdom, to be transferable to new situations, the knowledge and skills should be acquired independent of their use of contexts (Berryman, 1991). Situated cognition point out that the transfer between learning situation in school and situation out-of-school is difficult, because learning activities in school do not include the activities of real situation. After all, the important problem is how we connect understanding made by participating in everyday cultural practices and learning taught in school.

This study investigates the comparative effectiveness of two kinds of instructional methods in transfer of mathematics learning, and the influences of the situated learning (SL) in transfer of mathematics learning.

To investigate these issues, the following five research questions were addressed:

1) Is there any significant difference between SL group and traditional learning (TL) group in the computational test?
2) Is there any significant difference between SL group and TL group in the problem-solving test?
3) Is there any significant difference between SL group and TL group in the real situation test?
4) Is there any difference between SL group and TL group in the method of computation and problem solving?
5) Is there any difference between SL group and TL group in the recognition of

context resources given in the story problems?

Questions 1-3 were intended to compare the effectiveness of the SL in transfer by statistical analysis. Question 4-5 addressed the influences of the SL in transfer of mathematics learning by qualitative research.

2. METHOD

2.1. Subjects and Design

Two classes of second grade children were selected from an elementary school in Chongju. The two classes were assigned to SL group (43 children) and TL group (44 children), respectively. 87 children participated in this study, but 6 children (3 from each group) missed one or more days during the time the study was conducted and they were subsequently dropped from the data analyses.

In this study, a non-equivalent control group design was used, and qualitative research was conducted. Qualitative data were collected 3 times interviews conducted with six children from the SL group and six children from the TL group.

2.2. Instruments

The three kinds of instruments were used: a questionnaire, pretest and posttest, interview. The questionnaire was intended to investigate the children's shopping experiences, which was administered to the parents.

A pretest was designed to assess the children's ability of mathematics and to check whether the both groups (SL and TL) are the same in mathematics ability before the treatment. The contents of the test were computation of addition and subtraction of the two-digit numbers and story problems of addition and subtraction.

Three sets of posttest were assessed: Written Test 1, Written Test 2 and real situation test. Written Tests 1 and 2 were to show the difference between SL group and TL group in computation and problem solving. The content of Written Test 1 was three-digit addition (6 items) and subtraction (6 items). And Written Test 2 consisted of computational problems and story problems. The computational problems of Written Test 2 were almost the same as Written Test 1 except attaching "*won*" (the basic monetary unit of Korea) after numbers

The story problems were about shopping context, and required computation to solve it. The contents and level of these story problems were almost the same with the problems that were learned in treatment. The other posttest involved in this study was real situation test, which was intended to assess the children's ability of problem solving in shopping situation. Two questions were asked. The children had to buy something asked in the test and compute the price and get the change exactly. This real situation test was scored on two-point scale, using the following criteria for scoring:

A. Question 1: Buying two bottles of beverages with 900 won

1 point: the child bought two bottles of beverages and got the change exactly.
0 point: the child was unable to understand the question or got the change wrongly.

B. Question 2: Buying goods with 500 won

1 point: the child bought all together 500 won worth of goods exactly.
0 point: the child was unable to understand the question or the total price of goods was less than 500 won or more than 500 won.

Three times of interviews were attempted to analyze the children's thinking in the process of solving the problems. The first interview was done just after pretest, and the second interview was done just after Written Test 1, and the third interview was just after Written Test 2. The interview allowed us to investigate not only the methods used by the children during their problems-solving attempts but also their thinking behind those methods.

2.3. Procedure

Both groups of children completed a written pretest. This task was completed in the regular classroom setting by the teacher of that class.

Three days after completing the pretest, the treatment was initiated. The children in SL group were grouped into 4 children. They were required to buy some goods and compute the price of goods and the change in the classroom store. For this, the two simulated stores were made in the classroom. The researcher and supporter managed the stores. The teacher's role was not teaching computation and problem solving, but rather providing advice and hint in-group activities. Seven sets (1 hour each day) of tasks were provided, and real money was used. The children were asked to select the goods, which they prefer in the tasks. And the children were required to find their own computation methods, not learn standard methods in the textbook. The teacher also didn't teach algorithm for addition and subtraction. After finishing individual task, the children in SL group participated in group-discussion. In this discussion, the children talked about the goods and the price of what they bought.

The TL group received instruction in three-digit addition, subtraction and story problem solving for 7 days (1 hour each day). The teacher explained the standard algorithm for addition and subtraction that was the same in the textbook. Then the children solved several exercise problems and the teacher commented or corrected wrong solutions. After exercising computation, the children learned story problems, which were almost the same with the SL group's tasks. The children in TL group were required to apply the computational method, which was learned into story problems.

After both groups completed the instruction, the posttests were administered. Written Test 1 was completed one day after finishing instruction in the classroom during 30 minutes. The real situation test was assessed one day after completing Written Test 1 during 4 hours in each classroom. Written Test 2 was administered three days after completing real situation test during 40 minutes in the classroom.

3. RESULTS

3.1. Quantitative Results (1)

1. Pre-test: Written assessment of mathematical ability

The T-Test was carried out to determine if there was significant difference between SL group and TL group in mathematical ability. As can be seen in the Table 1, there is no significant difference between SL group and TL group in computation and problem solving. So, we can say that the two groups are almost the same in the ability of mathematics.

Table 1.
T-Test for mathematical ability (computation and problem solving)

	Group	N	M #	SD	Df	T	P
Computation	SL	41	11.073(12)	1.587	79	–.23	.819
	TL	40	11.175(12)	2.341			
Problem Solving	SL	41	6.000(8)	1.803	79	.00	1.000
	TL	40	6.000(8)	1.633			

The numbers in a parenthesis are maximum score

2. Post-test 1: Written assessment of computational skill

The T-Test showed that the two groups did not differ in computation skill in the both cases of Written Test 1 and 2 (see Table 2). This meant that TL group that learned standard algorithm would not perform better than SL group that did not learn standard algorithm.

3. Post-test 2: Written assessment of problem solving

The T-Test was used to analyze the effects of SL in story problem solving. As can be seen in the Table 2, the analysis of T-Test indicated that SL group performed better than TL group.

Table 2.
T-test for computation skill (Written Tests 1 and 2)

	Group	N	M #	SD	Df	T	P
Computation	SL	41	10.658(12)	1.460	79	1.46	.148
	TL	40	10.000(12)	2.481			
Problem Solving	SL	41	13.805(16)	3.092	79	.71	.483
	TL	40	13.275(16)	3.637			

The numbers in a parenthesis are maximum score

Table 3
T-test for problem solving (Written Test 2*)*

Group	N	M #	SD	Df	T	P
SL	41	6.050(8)	2.180	79	–3.52	.001 (P<.05)
TL	40	4.122(8)	2.731			

The numbers in a parenthesis are maximum score

4. Post-test 3: Real situation test

Two questions were asked to assess the children's problem solving ability in the context of shopping. 67.5% of TL group performed correctly the first question but 87.5% of SL group performed it. But, for the second question, 60% of SL group performed it correctly, whereas only 35% of the TL group performed it.

3.2. Qualitative Results (2)

1. Differences of computation method

The data collected in the three sets of interviews served to investigate and analyze the children's thinking in the solving of problems. According to data of interviews, SL group differed from TL group in the methods of solving the computation problems and story problems. Three major differences can be derived:

1) SL group did addition and subtraction by 10 won which was the basic monetary unit of Korean, whereas TL group did them by digit-by-digit.
2) SL group computed from left digit (i.e., the digit of "hundred") to right digit (i.e., the digit of "one"), whereas TL group computed from right digit to left digit which

was standard algorithm.

Lee, J. and Park, M. S. belong to TL group and Nam, H. A. and Lee, B. R. belong to SL group. In the excerpt, Nam, H. A. and Lee, B. R. computed by won (the monetary unit of Korean) and from left digit to right digit.

Interviewer:	Look at here. How did you do Number 6 (900 won – 270 won)?
Nam, H. A.:	Subtracted 7, 70 won from 100 won, so 30 won.
Interviewer:	Ah, 70 won from 100 won.
Nam, H. A.:	Subtracted 200 won from 800 won…
Interviewer:	How did you solve this problem (470 won + 290 won)?
Lee, B. R.:	Addition. At first, subtracted 10 won, and them added 400 won and 200 won, and then added 70 won, and 90 won.

But Lee, J and Park, M. S. computed digit by digit and from right digit to left digit.

Interviewer:	How did you solve this problem (620 won – 190 won)?
Lee, J.:	Subtracted 0 from 0, and 9 from 1(carried) and them added 2, subtracted 1 from1,
Interviewer:	How did you solve this problem (560 won + 390 won)?
Park, M. S.:	Added 0 and 0 then 0, and added 9 to 6 then got 5, added 3 to 5 then got 8, so 9.

3) In the problem of buying two items and finding the change, TL group added the prices of two items at first and then subtracted it from the total money to get change. But SL group subtracted the price of one item from the total money and then subtracted again the price of another item from the remainder to get change.

2. *Differences of recognition of context resources*

There was also difference between SL group and TL group in recognition of context resources given in the problems. Whereas TL group recognized even computation problems that were attached "won" after numbers as computing numbers, SL group considered them as computing money. Also, when solved written story problems, the children of SL group trended to solve them by thinking they were buying goods really.

Interviewer:	How did you solve this problem (560 won + 390 won)?
Park, M. S.:	Added 0 and 0 then 0, and added 9 to 6 then got 5, added 3 to 5 then got 8, so 9.
Interviewer:	What did you compute in this problem?
Park, M. S.:	Hmm … Numbers.
Interviewer:	What did you do in this problem?
Lee, S. R.:	Number.

In the excerpt from above, we can see Park, M. S. and Lee, S. R. recognized computation problems as just computing numbers, even though the computation problems were attached “won” after numbers. But Nam, H. A. and Lee, B. R. recognized that problems as computing money instead of numbers.

Interviewer:	Look at here. How did you do Number 6(900 won – 270 won)?
Nam, H. A.:	Subtracted 7, 70 won from 100 won, so 30 won
Interviewer:	Ah, 70 won from 100 won.
Nam, H. A.:	Subtracted 200 won from 800 won…
Interviewer:	What did you compute in this problem?
Nam, H. A.:	Money.
Interviewer:	How did you solve this problem (470 won + 290 won)?
Lee, B. R.:	Addition. At first, subtracted 10 won, and them added 400 won and 200 won, and then added 70 won and 90 won.

In particular, as the reason why they do computation is concerned, the children of SL group considered it as an activity required in buying something in the store, whereas the children of TL group considered it as computing the numbers given in the problems to solve them.

Problem 6 of Written Test 2: Mother gave me 800 won and asked me to buy 2 bottles of coke. The price of one bottle is 370 won. How much left?

In the excerpt below, Lee, B. R. solved the problem if she buy coke in the supermarket.

Interviewer:	Did you regard “me” in this problem as you (i.e. Lee, B. R.)?
Lee, B. R.:	Yes.
Interviewer:	What did you in this problem?
Lee, B. R.:	Computed money and change…
Interviewer:	What did you think during solving this problem?
Lee, B. R.:	Buying goods…
Interviewer:	Where do you use this computation?
Lee, B. R.:	Computing addition and subtraction.
Interviewer:	Computing what?
Lee, B. R.:	Buying something,

But for the TL group, the context resources in the problem was not important, and given problem situation had no relation with problem solvers themselves. Lee, J. just computed numbers in the problem and thought that computation is only helpful to solve problems in the school.

Interviewer:	Did you regard “me” in this problem as you (Lee, J.)?

Lee, J.:	No.
Interviewer:	Do you think the problem like this can happen around us?
Lee, J.:	No.
Interviewer:	You learned addition and subtraction. Where can you use this?
Lee, J.:	In solving problems.

4. DISCUSSION

The purpose of this study was to investigate the comparative effectiveness of two learning methods, one based on the situated cognition (SL group) and the other traditional classroom-based learning (TL group), and the influences of SL in transfer of mathematics learning. I would like to discuss the results of this study upon previous relating studies.

First, although the TL group learned standard algorithm, there were no significant differences between SL group and TL group in computation ability. The SL group developed their own computational methods and used them. These informal methods are natural and efficient for them. This meant that the SL didn't reduce the computation ability, though it didn't teach standard computation algorithm.

Secondly, in this study, transfer was meant by transferring from school based learning to out-of school learning or from out-of school to school based learning. To show the effectiveness of SL in transfer, two sets of test were administered: story problem test, real situation test. The SL group got score significantly higher than TL group on those two tests. In particular, the point is that SL group performed better on story problem. Thus, SL enhanced not only the performance on the real situation tasks, but also the written story problems given in school. This result is consistent with the study of Cognition and Technology Group at Vanderbilt (1990, 1991).

Thirdly, this study was started from two assumptions:

1) The SL group will be better than TL group on the performance of real situation task, and then the knowledge will transfer to the activity on the written story problems given in school.
2) Transferable knowledge will be influenced by the interaction with context resources.

Indeed, there were differences on recognition of context resources between two groups. Since the knowledge is developed in context which that knowledge is used (Larkin, 1989; Perkins & Salomon, 1989). Indeed, there were differences on recognition of context resources between two groups. The children of SL group had tendency to relate the context provided in story problem with themselves and used it in solving the problem. Thus, the shopping activity in the SL learning was transferred into the written story problem solving, which was generally provided in school.

5. CONCLUSION

In this study, the effectiveness of SL based on situated cognition and the context-bounded nature of transfer was investigated. This study support that cognition is situated in the context and knowledge is developed in the interaction between individual and situation, is not separated from the situation. As a result of this study, the children as situated learner (SL group) were able to connect the knowledge acquired in shopping situation to school-based problems. This suggests that the ability of using context resources in one situation be transferred to that in another situation.

The SL not only had effects on transfer of learning, but also was a good way to connect informal everyday mathematics and formal school mathematics. Furthermore, the children participating in SL enjoyed this type of instruction and were more motivated to authentic activity. They recognized the need of computation and developed computation methods naturally. In this point, the mathematics learning in school should not be merely mental activity in the brain, but rather authentic activity in situation which the mathematics is used and developed.

REFERENCE

Berrymen, S. F. (1991). *Designing effective school-based learning environments: Cognitive apprenticeship models*. http://www.ilt.columbia.edu/ilt/ papers/berry1.html.

Brown, Collins & Drugged. (1989). Situated cognition and the culture of learning. *Educational Researcher* **18(1)**, 32-42.

Carraher, T. N.; Carraher, D. W. & Schliemann, A. D. (1985). Mathematics in the streets and in schools. *British Journal of Developmental Psychology* **3**, 21-29.

Cognition and Technology Group at Vanderbilt (1990). Anchored instruction and its relationship to situated cognition. *Educational Researcher* **19(6)**, 2-10.

Collins, A., Brown, J. S., & Newman, S. (1989). Cognitive apprenticeship: teaching the craft of reading, writing, and mathematics. In L. B Resnick (Ed.), *Cognition and instruction: Issues and agendas*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Greeno, J. G., Moore, J. L., & Smith, D. R. (1993). Transfer of situated learning. In D. K. Detterman & R. J. Sternberg (Eds.), *Transfer on trial: Intelligence, cognition, and instruction* (pp. 99-167). Norwood NJ: Ablex Publishing Corporation.

Griffin, M. M. (1995). You can’t get there from here: Situated learning, transfer, and map skills. *Contemporary Educational Psychology* **20**, 65-87.

Harley, S. (1991). *A study of situated cognition for third and fourth grade students doing math word problems*. Doctoral dissertation, Ohio State University.

Laboratory of Comparative Human Cognition (1983). Culture and cognitive development. In W. Kessen (Ed.), *Handbook of child psychology: Vol. 1. History, theory, and methods* (pp. 295-356). New York: John Wiley & Sons.

Larkin, J. H. (1989). What kind of knowledge transfer? In L. B. Resnick (Ed.), *Knowing, learning and instruction* (pp. 283-305). Hillsdale, NJ: Lawrence Erlbaum Associates.

Lave, J. (1988). *Cognition in practice*. New York: Cambridge University Press.

Lave, J. & Wenger, E. (1995). *Situated learning: Legitimate peripheral participation.* New York: Cambridge University Press.

McLellan, H. (1993). Situated learning in focus: Special issue. *Educational Technology* Mar. 5-8.

Newman, D.; Griffin, P. & Cole, M. (1989). *The construction zone: Working for cognitive change in school. New York*: Cambridge University Press.

Perkins, D. N. & Salomon, G. (1988). Teaching for transfer. *Educational Leadership* **46(1)**, 22-32.

Resnick, L. B. (1987). Learning in school and out. *Educational Researcher* **16(9)**, 13-20.

Rogoff, B. (1990*). Apprenticeship in thinking*. New York: Oxford University Press.

Rogoff, B. (1993). Social interactions as apprenticeship in thinking: Guidance and participation in spatial planning. In L. B. Resnick, J. M. Levine & S. D. Teasley (Eds.), *Perspectives on society shared cognition* (pp. 349-364). Washington, DC: American Psychology Association.

Saxe, G. B. (1991). *Culture and cognitive development: Studies in mathematical understanding*. Hillsdale, NJ: Erlbaum.

Schoenfeld, A. H. (1985). *Mathematical problem solving*. New York: Academic Press.

Scribner, S. (1984). Studying working intelligence. In B. Rogoff & J. Lave (Eds.), *Everyday cognition* (pp. 117-138). Cambridge, MA: Harvard University Press.

St. Julian, J. (1994). *Cognition and learning: The implications of a situated connectionist perspective for theory and practice in education*. Doctoral dissertation, Louisiana State University.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* Cambridge, MA: Harvard University Press.

Wertsch, J. V. (1985). *Vygotsky and the social formation of mind*. Cambridge, MA: Harvard University Press.