Piagetian cognitive developmental level and learner control as instructional design variables in CAI

Young-Soo Kim*

(1986년 11월 5일 받음)

I. INTRODUCTION

In recent years, computers have become increasingly available to education. Much research has been done with the aim of implementing the computer as a useful tool in education. Many educators are in agreement that the most significant problem affecting the use of CAI as a classrom tool today is the need for high quality and reliable hardware, software, and courseware. For effective learning with computers, the development of CAI materials must be based on sound learning theories. In the past, however, most theoretical and empirical work in CAI has been based on the learning theory of behaviorists. There has been no sustained or serious attempt to apply the cognitive developmental psychology to the pedagogical development of CAI(Computer Assisted Instruction)

Piagetian cognitive developmental theory has been very influential in science education. Survey studies in the secondary school show that all the students do not reach the formal operational level of cognitive development. Over 50% of students were still in a concrete operational level and could not deal with formal thoughts, which are frequently required in science content (Chiappetta, 1976). Thus, these findings suggested that the content and the instruction of science should be matched with the level of the students cognitive developments (Wadsworth, 1984). Based on these observations, the Piagetian cognitive developmental theory should be serlously considered also in developing the CAI materials for science instruction.

Also, students need to have free active role in their learning in order to become successful learners because they construct knowledge in an active way. In science education, one of the strategies that can be used to help students become successful in learning is to place them in control of their own learning process. A number of studies have suggested that this behavioral self-regulation gives a potential effectiveness in learning. The major premises of learner control in learning are more motivation, greater task engagement, better performance, faster learning, improved attitude, reduced anxiety and so forth (Steinberg, 1977). Piaget (1971) also emphasized the importance of free activity in learning situation.

The theoretical position that learning is enhanced when instructional design is matched to the student cognitive level and preferred mode of delivery suggests that students of varying Piagetian level may perform better on CAI when allowed to select an instructional sequence commensurate with their ability as

*The author is an instructor on science education at College of Education, Seoul National University.

opposed to a prescribed instructional sequence that is enforced and may not be optimum for the student.

Based on this rationale, this study examined what the effect was on the achievement of concrete and formal operational students when Piagetian cognitive developmental psychology was used to develop a rationale for experimentally examining alternative strategies for CAI program development. The flexibility of programming allows us to program the CAI to match the student's cognitive level and preferred mode of delivery and thereby determine which of several instructional sequences is optimum for students of varying cognitive level.

The purpose of this study was to determine whether prescribed instruction based either on concrete or formal level of thought results in differential learning by students of varying Piagetian cognitive developmental level compared to a student-controlled sequence. The student-controlled sequence permits the learner to choose the next step in instruction based on their perception of the most appropriate kind of information and format from the varied Piagetian cognitive developmental levels provided concrete operational level and formal operational level instructions. Hence, in the latter strategy, the learner creates the sequence of instruction from the options provided and should be able to create a sequence optimally matched to his / her cognitive level.

This study was directed toward examining the effectiveness of three different instructional procedures in CAI with concrete and formal operational students--prescribed concrete operational level instruction, prescribed formal operational level instruction, and student-controlled optional instruction.

II. MATERIALS AND METHODS

Research Design

The design of the study is summarized in the following paradigm, which is a modification of Posttest-Only Control Group Design from Campbell and Stanley (1966).

OL	RM	Xc	OP
OL	RM	Xf	OP
OL	RM	Xs	OP

The OL's repesent the Longeot Test and the Op's indicate the performance test. The RM's represent the matched random assignment. The symbols Xc, Xf, and Xs refer to the use of the three treatments, respectively:prescribed concrete level instruction, prescribed formal level instruction, and student-controlled optional instruction.

Subjects

The subjects of this study were 102 ninth (n=60) and tenth (n=42) grade students in four physical science classes(n=51) and four biology classes(n=51) at Greensboro Day School in North Carolina state. Their age range was from 13.4 years to 16.4 years and mean age was 14.9 years. Forth-two students were females with mean age of 14.8 years and 60 students were males with mean age of 15.0 years.

They were randomly assigned with matching technique to one of three treatment groups. Thirty three students (18 males and 15 females) were assigned to the concrete operational level instruction group, thirty four students (17 males and 17 females) were assigned to the formal operational level instruction group, and thirty five students (25 males and 10 females) were assigned to the student-controlled optional instruction group. One female student from the formal level instruction group was absent on the date of the computer instruction.

The participants did not learn about the experimental content diffusion and osmosis before this experiment. They were average in intellectual ability and most of them had had some experience with a computer. The school was an affluent suburban high school, and the students come from families of middle and upper middle socioeconomic status.

Materials

(1) The Longeot Test of Cognitive Development

As the measure of concrete and formal thinking ability a paper-and-pencil test developed by Longeot(originally consisting of 28 nonscience content problems) was administered to all the students. In order to allow its administration during one class period(45 minutes) of Greensboro Day School, Lawson's short version of the Longeot test(Lawson & Blake, 1976) was selected.

The classification of the subject's cognitive developmental level was done according to the procedures described by Lawson and Blake (1976). The Longeot test score was computed according to Ward's method (Ward, Nurrenbern, Lucas, & Herron, 1981).

(2) CAI Materials

On the topic of diffusion and osmosis, three different tutorial types of CAI materials were developed using Apple super PILOT authoring language on the Apple IIe computer. These instructional materials consisted of seven short units of lessons : (a) random motion, (b) diffusion, (c) equilibrium, (d) diffusion through cell membrane, (e) semipermeability of cell membrane, (f) osmosis, and (g) passive transport and active transport.

Three tutorial types of CAI were: (a) prescribed concrete operational level instruction, (b) prescribed formal operational level instruction, and (c) student-controlled optional instruction. In the student-controlled optional instruction, two short lesson descriptions--one at the formal operational level and the other at the concrete operational level--were given at the beginning of each unit of a lesson so that the students could select the one they preferred for the following lesson. In the prescribed level instructions, the same lesson descriptions were given at the beginning of each unit without an option and the level of exposition was prescribed at a consistent level with their Piagetian developmental level.

In programming the concrete operational level instruction, real concrete materials or events were used. When two or more variables were involved, only one was presented at a time. Nonhypothetical statements were employed and deductive reasoning was eliminated. Whereas formal operational level instruction used propositions and hypothetical situations along with deductive statements. Abstract symbolic graphics and mathematical notations were used and the consideration of all possible variables were required for formal operational level lessons. The Piagetian levels of instructional programs were validated by two science deucators who examined them for content validity.

(3) Performance Test

A performance test consisted of both formal and concrete operational level questions and were presented at the end of the instructional program. These on-line tests consisted of 17 multiple choice questions testing the objectives of the lesson. Eight questions were concrete operational level and 9 questions were formal operational level. All the students had the same performance test and each student's responses were recorded in a data file by the computer.

Procedures

This study was conducted at the end of September in 1985.

No pretest was administered since this content was new to the students and the randomization of subjects should make the groups equal with respect to initial knowledge except for variations by chance.

One hundred and two students were administered the Longeot Test during a single class period on the first day of the study and were placed in rank order on the basis of their scores. The first three subjects were selected and by random means each subject was assigned to one of the three experimental groups. The next three subjects were randomly assigned in the same way. This procedure was continued until all the subjects were assigned.

Three days after the Longeot test administration,

each student sat for the computer alone and received individually one of the three different computer instructions. This lasted an average of 40 minutes on the Apple IIe microcomputer with green monitor or black and white mode in color monitor.

The performance test was presented at the end of instructional program on the computer.

All the responses of each student during the instruction and test were recorded by the computer for later statistical analyses. In order to compare the data among the three treatment groups, one-way analyses of variance were used. The 0.05 level of significance was chosen as a critical level for the rejection or acceptance of the null hypotheses. These statistical analyses were done sing the SPSS on the Digital-20.

Ⅲ. RESULTS

Students' Cognitive Developmental Levels

Table 1. Distribution of Piagetian Cognitive Developmental Level

	ⅡA	ⅡB	ⅢA	ⅢB	N
Total Students	4 (3.92%)	38 (37.25%)	48 (47.06%)	12 (11.76%)	102
Concrete Level Instruction Group	1 (3.03%)	13 (39.39%)	15 (45.45%)	4 (12.12%)	33
Formal Level Instruction Group	1 (2.94%)	13 (38.24%)	16 (47.06%)	4 (11.76%)	34
Student-controlled Optional Instruction Group	2 (5.71%)	12 (34.29%)	17 (48.57%)	4 (11.43%)	35
Boys	3 (5.00%)	20 (33.33%)	28 (46.67%)	9 (15.00%)	60
Girls	1 (2.38%)	18 (42.86%)	20 (47.62%)	3 (7.14%)	42

ⅡA=early concrete operational level　ⅢA=early formal operational level
ⅡB=fully concrete operational level　ⅢB=fully formal operational level

The results of the Longeot Test indicated that 3.92% of the subjects were at the early concrete operational level (ⅡA), 37.25% at the fully concrete operational level (ⅡB), 47.06% at the early formal operational levl(ⅢA), and 11.76% at the fully formal operational level (ⅢB). The distribution of the cognitive developmental levels of subjects is summarized in Table 1.

Comparisons of Performance Test Scores among the Treatment Groups

Table 2 shows the means, standard deviations, and sample sizes for the performance test and the results of one-way analyses of variance among the treatment groups. The numbers of students for the concrete level question score and the formal level question score were different from those of the complete test score because the responses of a few students from concrete level and formal level instruction group were not saved properly on the computer. The data of twenty two from thirty three students in the concrete level instruction group and the data of nineteen from thirty three students in the formal level instruction group were abailable for the analysis of question breakdown.

Table2. Performance test Scores by Student Cognitive Levels and Treatment Groups and One-way ANOVA in Performance Test Score by Treatment Groups

	Instruction Groups			One-way ANOVA	
Students	Concrete Level	Formal Level	Optional	*F*-ratio	*F*-prob
Complete Test (No. of items=17)					
All Levels					
Mean	9.45	9.30	8.20	2.422	0.094
S.D.	2.27	2.28	2.55		
N	33	33	35		
Concrete Level					
Mean	8.57	8.00	6.93	1.941	0.158
S.D.	2.53	1.83	2.27		
N	14	13	14		
Formal Level					
Mean	10.11	10.15	9.05	1.238	0.298
S.D.	1.85	3.15	2.42		
N	19	20	21		

Concrete Level Questions(No of items=8)					
All Levels					
Mean	5.77	6.11	4.94	3.660	0.031*
S.D.	1.57	1.63	1.66		
N	22	19	35		
Concrete Level					
Mean	5.00	5.50	4.07	1.996	0.156
S.D.	1.77	1.77	1.59		
N	8	8	14		
Formal Level					
Mean	6.21	6.55	5.52	2.156	0.128
S.D.	1.31	1.44	1.47		
N	14	11	21		

Formal Level Questions(No of items=9)					
All Levels					
Mean	3.41	3.68	3.26	0.471	0.626
S.D.	1.44	1.95	1.36		
N	22	19	35		
Concrete Level					
Mean	3.13	2.75	2.86	0.187	0.831
S.D.	1.46	0.89	1.35		
N	8	8	14		
Formal Level					
Mean	3.57	4.36	3.52	1.074	0.351
S.D.	1.45	2.25	1.33		
N	14	11	21		

* Significant at an α of 0.05

The results in Table 2 indicated that, for the complete test score, the concrete level instruction group achieved the highest, the formal level instruction group achieved the next highest, and the student-controlled optional instruction group achieved the lowest. However, analyses of variance performed on these data showed no significant difference among treatment groups.

Scores for the concrete level questions of the all level students were as follow : (a) the concrete level instruction group had a mean of 5.77 with a standard deviation of 1.57, (b) the formal level instruction group a mean of 6.11 with a standard deviation of 1.63, and (c) the student-controlled optional instruction group a mean of 4.94 with a standard deviation of 1.66. ANOVA revealed a significant difference among treatment groups $F=3.660$. $p<0.05$). Scheffé post comparisons showed that there was a significant difference between the formal level instruction group and the studentcontrolled optional instruction group at an $\alpha=0.05$. However, for the concrete level students and the formal level students, no significant differences were found among the treatment groups.

In the score of formal level questions, the formal level instruction group had the lowest score for the concrete level students (mean of 2.75 with a standard deviation of 1.17), whereas the highest score for the formal level students (mean of 4.36 with a standard deviation of 2.25). There was no overall significant difference among treatment groups. They had very low mean scores.

Comparisons of Performance Test Scores among the Reorganized Treatment Groups

Those subjects who selected consistently only concrete or formal level instruction in the student-controlled optional instruction group were reassigned to the concrete level instruction group or the formal level instruction group respectively. The data of these reorganized treatment groups were analyzed using the same statistical procedures as those of the original groups. These were done to examine whether the group which alternated formal and concrete level instructions would have any differences in performance from those who received consistently concrete or formal level instruction.

The means, standard deviations, and sample sizes for the performance test in the reorganized groups and the results of ANOVA are reported in Table 3.

In the complete test score, only the concrete level students showed a significant difference among the treatment groups ($F=5.340$, $p<0.01$). Scheffé post comparison showed there was a significantly higher score for the concrete level instruction group compared to the student-controlled optional instruction group at an $\alpha=0.05$.

Table 3. Performance Test Scores by Student Cognitive Leveis and Reorganized Treatment Groups and One-way ANOVA in Performace Test Score by Reorganized Treatment Groups

Student	Instruction Groups: Concrete Level	Formal Level	Optional	One-way ANOVA: F-ratio	F-prob
Complete Test (No. of items = 17)					
All Levels					
Mean	9.25	9.26	8.00	2.098	0.128
S.D.	2.20	2.77	2.88		
N	40	38	23		
Concrete Level					
Mean	8.61	8.00	5.75	5.340	0.009**
S.D.	2.38	1.73	1.91		
N	18	15	8		
Formal Level					
Mean	9.77	10.09	9.20	0.543	0.584
S.D.	1.95	3.03	2.60		
N	22	23	15		
Concrete Level Question (No. of item = 8)					
All Levels					
Mean	5.52	6.04	4.83	3.257	0.044*
S.D.	1.60	1.55	1.77		
N	29	24	23		
Conrete Level					
Mean	4.83	5.40	3.63	2.621	0.091
S.D.	1.75	1.58	1.60		
N	12	10	8		
Formal Level					
Mean	6.00	6.50	5.47	1.909	0.161
S.D.	1.32	1.40	1.55		
N	17	14	15		
Formal Level Questions (No. of items = 9)					
All Levels					
Mean	3.45	3.58	3.17	0.428	0.653
S.D.	1.35	1.79	1.50		
N	29	24	23		
Concrete Level					
Mean	3.50	2.80	2.13	3.511	0.044*
S.D.	1.38	0.92	0.99		
N	12	10	8		
Formal Level					
Mean	3.41	4.14	3.73	0.769	0.470
S.D.	1.37	2.07	1.44		
N	17	14	15		

* Significant at an α of 0.05

** Significant at an α of 0.01

In the score of concrete level questions, for the all level students, the concrete level instruction group had a mean of 5.52 with a standard deviation of 1.60, the formal level instruction group a mean of 6.04 with a standard deviation of 1.55, and the student-controlled optional instruction group a mean of 4.84 with a standard deviation of 1.77. ANOVA on these data showed a significant difference among treatment groups (F= 3.257, p<0.05) and Scheffé post comparison showed a significant difference between the formal level instruction group and the student-controlled optional instruction group at an α=0.05. Breakdown of the students' cognitive developmental levels did not revealed any significant difference among treatment groups.

For the score of formal level questions, the concrete level students showed a significant difference among the treatment groups(F=3.511, p<0.05). The concrete level instruction group had a mean of 3.50 with a standard deviation of 1.38, the formal level instruction group a mean of 2.80 with a standard deviation of 0.92, and the student-controlled optional instruction group a mean of 2.13 with a standard deviation of 0.99. Scheffé post comparison showed a significant difference between the concrete level instruction group and the student-controlled optional instruction group at an α= 0.05. Unlike the concrete level students, the formal level students had the highest mean score in the formal level instruction (mean of 4.14 with a standard deviation of 2.07), however, they did not show any significant difference among treatments.

Ⅳ. DISCUSSION

The results of the Longeot test (Table 1) gives an implication of what and how students should be taught.

About 41% of students were at a concrete operational level. They need help through carefully constructed learning sequences progressing from concrete to formal levels in ordre to develop formal operational thought. The students at an ealy formal operational level (47%) still need additional instruction which will give them more opportunites for practicing formal operations. Without enough practice of formal operation, they very likely will regress to the concrete level of thinking when they meet new learning tasks even though they have the ability to do formal level of thinking.

Regardless of instructional modes, formal operational students achieved higher scores on the performance test than concrete operational students (Table 2 and 3). These results suggest that cognitive developmental level is an important factor in CAI and that design of CAI material should also consider the cognitive dvelopment of the students involved. Edwards (1970) also argued that the design of CAI at a concrete level for all age levels is more of regression to a earlier mode of cognitive ability. As age increases there is an increase in the ability to comprehend and manipulate abstract concepts and relationships without concrete and direct experience. As Lindelow (1983) suggested, a matching approach is desirable which periodically exposes students to demands that do not precisely match their styles in order to develop their flexibility and ability to select appropriate strategies for particular learning context.

The results of one-way ANOVA (Table 2) showed no significant difference among the treatments for the complete test score. However, when only concrete questions were analyzed, it showed a significant difference. Scheffé post comparison showed there was a significantly higher score for the formal level instruction group. Whereas, formal questions did not show any significant difference. This can be explained when we consider the score on formal questions. The number of formal items was 9 and their means for each group were very low (lower than 4.5). Thus, this floor effect undoubtedly limited the possibility of finding significant differences among the treatment groups.

The student-controlled optional instruction group did not have higher scores than the prescribled instructional groups. To the contrary, always the student-controlled optional instruction group had the lowest mean value for the performance test even though all the comparisons were not significant. This is highlighted in the reorganized groups (Table 3). In the reorganized groups, concrete level students showed significant differences in the complete test score and formal question score. Thus, concrete level students seemed to have poor learning in the student-controlled instruction sequence. Whereas, formal level students did not show any significant difference. The lowest mean obtained by the student-controlled optional instruction group is thought to be due to the erratic choice of instructional structures which alternate formal and concrete operational levels from the outset of each unit, and thus students may have introduced too much variability into their learning experiences. Formal operational students could somewhat manage this instruction, and consequently did not show any significant difference. But, concrete operational students could not, and thus showed significant differences in complete test score and formal question score. This finding gives an implication to the instructional design of CAI, The instruction should not be organized in a totally different way from the previous unit from the beginning. It should begin by giving some introductory information (advance organizers) in concrete level and then proceed to formal level.

The learning processs is serial with only a limited amount of information assimilated within a given unit of time. Therefore, the order of the presentation of infromation shouldd be considered in the learning process and in the organizing instructional structure. Anderson's (1971) theory of structure provides an idea of how to structure the CAI materials. Especially, tutorial mode of CAI contains a lot of serial presentations of information. High structure of material will facilitate far more acquisition of knowledge, even in CAI, and concrete level students will benefit more than formal level students. Rawwas' (1985) study supports the ap-

plication of high structure in designing CAI material. He also found that the high structure communication counteracted the effect induced by difficulty and abstractness of the lesson. This suggests that the high structure communication in the formal level instruction may conteract some abstractness of information and thus facilitate learning of formal level students. By using the high structure communication in concrete level instruction, the acquisition of knowledge for both concrete and formal level students will be enhanced. Moreover, as found in this study in some learning concepts, students who assemble their own learning sequence may unwittingly disarrange their learning to such an extend that they suffer a loss in acquisition. Flexible and interactive CAI must also be cleverly desgned to ensure that adequate structure is maintained throughout the potential range of sequences the learner may assemble during instruction. In the present case, although the instructional sequence in all options was the same, varying only in level of formal thought, nevertheless, the alternation between concrete and formal presentation level apperars to have interrupted an essential structural continuum needed to maintain information acquisition.

Further explanations arise from other research findings (Atkinson, 1972; Bunderson, 1976: Tennyson & Rothen, 1979). They found that when the students were given a choice for the instructional strategy, they were not effective decision makers and they needed advice on making their decisions The results of concrete operational students are explained by this notion. When they chose a formal level of instruction, they couldn't deal with it competently. They needed some advice or infromation about their success in selecting the instructional level.

Nonexistence of significant difference between concrete and formal level instructions is explained by the characteristics of CAI. The high interactiveness--involving the individual actively in the learning process, providing immediate feedback, and permitting the learner to proceed at his/ler own pace--may have interacted with the effect of instruction level. These advantages of CAI can be of help even though the instruction is abstract.

Since this study indicated that students might not be effective decision makers within the set of options provided, this study could be expanded to examine whether the student-controlled optional instruction will produce greater achievement when the advice or infromation about the success of learning is given. When they are given some information about their success, it could be assumed that they will be more discreet in selecting the lesson levels and that this instruction will yield more efficient learning.

BIBLIOGRAPHY

Anderson, O.R.(1971) *Quantitative analysis of structure in teaching*. New York:Teachers College Press.

Atkinson, R. C.(1972). Ingredients for a theory of instruction. *American Psychologist*, 27, 921−931.

Bunderson, C.V.(1976, April). *TICCIT courseware development report*. Paper presented at the meenting of the American Educational Research Association, San Francisco, CA.

Campbell, D.T., Stanley, J.C.(1966). *Experimental and quasi-experimental designs for research*. Boston, MA:Houghton Mifflin.

Chiappetta, E.L.(1976). A review of Piagetian studies relevant to science instruction at the secondary and college level. *Science Education*, 60(2), 253-261.

Edwards, T.O.(1970). *Optimizing computer assisted instruction by applying principles of learning theory*. (ERIC Document Reproduction Service No. ED 105899).

Lawson, A.E., & Blake, A.J.D.(1976). Concrete and formal thinking abilities in high school biology students as measured by three separate instruments. *Journla of Research in Science Teaching, 13(3)*, 227-235.

Lindelow, J.(1983). *The emerging science of individualized instruction:A survey of findings on learning styles, brain research and learning time with implications for administrative action*. Eugene, OR:ERIC Clearinghouse on Educational Management.

Piaget, J.(1971). *Science of education and the pshchology of the child*. New York:Viking Press.

Rawwas, M.A.(1985). *The effects of variation in sequential kinetic structure on acquisition of the mole concept in*

chemistry based on a hierarchical learning model using computer-based materials. Unpublished Ed.D. dissertа Teachers College, Columbia University.

Steinberg, E.R.(1977). Review of student control in computer-assisted instruction. *Journal of Computer-Based instruction, 3(3),* 84-90.

Tennyson, R.D., & Rothen, W.(1979). Management of computer-based instruction:Design of an adaptive control strategy. *Journal of Computer-Based instruction, 5(3),* 63-71.

Wadsworth, B. J.(1984). *Piaget's theory of cognitive and affective development*(3rd ed.). New York:Longman.

Ward, C. R., Nurrenbern, S. C., Lucas, C., & Herron, J.D.(1981). Evalua tion of the Longeot test of cognitive development. *Journ al Research in of Science Teaching, 18(2),* 123-130.

요 약

CAI 설계변인으로서의 Piaget 인지 발달 수준과 학습자의 수업조절(learner-control)

김 영 수

CAI 프로그램 개발에 Piaget의 인지 발달 이론과 학습자의 수업 조절(learner-control) 전략을 적용하기 위한 기초 연구로서, 미국의 North Carolina주에 있는 Greensboro Day School의 9학년과 10학년 학생 102명을 실험 대상으로 하여 인지 발달의 수준을 조사하고, 3그룹으로 나누어 그들에게 구체적 조작 수준의 CAI, 형식적 조작 수준의 CAI, 그리고 학습자가 수업의 수준을 선택·학습할 수 있는 CAI의 3가지 형태를 각각 학습시킨 후 학습의 효과성을 조사 비교하였다. 그결과는 다음과 같다.

1) 조사 학생들의 3.92%가 구체적 조작의 초기 수준(ⅡA)에, 37.25%가 구체적조작의 완전 수준(ⅡB)에, 47.06%가 형식적 조작의 초기 수준(ⅢA)에, 그리고 11.76%가 형식적 조작의 완전 수준(ⅢB)에 있는 것으로 나타났다.

2) 구체적 조작 수준의 문항에 대하여, 형식적 조작 수준의 CAI를 실시한 그룹은 학습자 수업 조절 CAI를 실시한 그룹보다 유의하게 높은 학업 성취도를 보였다($F=3.660$, $p=0.031$).

3) 구체적 조작 수준의 문항에 대하여, 형식적 수준의 수업만 학습한 그룹은 구체적 수준과 형식적 수준의 수업을 섞어서 학습한 그룹보다 유의하게 높은 학업 성취도를 보였다($F=3.257$, $p=0.044$).

4) 성취도 검사의 전체 문항에 대하여, 구체적 수준의 수업만 학습한 그룹의 구체적 수준의 학생들은 구체적 수준과 형식적 수준의 수업을 섞어서 학습한 그룹의 구체적 수준의 학생들보다 유의하게 높은 학업 성취도를 보였다($F=5.340$, $p=0.009$).

5) 형식적조작 수준의문항에대하여, 구체적수준의 수업만 학습한 그룹의 구체적 수준의 학생들은 구체적 수준과 형식적 수준의 수업을 섞어서 학습한 그룹의 구체적 수준의 학생들보다 유의하게 높은 학업 성취도를 보였다($F=3.511$, $p=0.044$).