Jour. Korean Earth Science Society, v. 25, no. 3, p. 176–184, March 2004

The Effect of The Lunar and Planetary Phases Drawing Module on Students' Conceptual Change and Achievement

Jong-Hee Kim* and Sang-Dal Kim

Department of Earth Science, Pusan National University,
30 Changjeon-dong, Keumjeong-ku, Pusan, 609-735, Korea

Abstract: The concept of 'the lunar and planetary phases' is very difficult to understand and students may have various misconceptions on this concept. A module drawing the lunar and planetary phases was developed with the application of the simplifying conditions method. The effects of instruction using the module drawing the lunar and planetary phases on the conceptual change and the achievement was investigated in the consideration of learners' characteristics (spatial perception ability, science inquiry ability, required pre-requested learning ability). Findings were as follows: 1) This module was effective for learners' conceptual change and achievement, 2) This module had a positive influence for development the learners' characteristics and conceptual change with the middle level of science inquiry ability, the middle and low level of required pre-requisite learning ability, and middle level of the spatial perception ability.

Keywords: conceptual change, lunar and planetary phases change, simplifying conditions method (SCM), module drawing the lunar and planetary phases.

Introduction

There have been many theoretical research studies on conceptual change. Previous studies proposed to develop practical instruction methods for correcting misconceptions and to apply them to instructions and to investigate the effects. There is a role play activity using a basketball in the science textbook. The objective of this role play is to understand the principle of the phases change. However when we asked students the reason of the lunar phases change after this role play, they had a tendency to answer that the Moon revolves around the Earth. But, after presenting the picture of relative positions, I asked students to draw the phase of any planet seen from the Earth. Students understood that the principle of changing phases is a considerably complex thing. Learners should know how to draw phases so that they understand the lunar and planetary phases change. Students have to understand the two following points at the first stages; One point is that the picture of position relations among planets is a plane figure and the other point is that the planetary phases which is its lateral face. Previous studies (Driver et al., 1985; Gilbert and Swift, 1985; Nussbaum and Sharoni-Dagan, 1983) made it clear that students have various misconceptions about the concept of 'the lunar and planetary phases change' and it is very difficult to understand. The reason is that learners lack abilities of generalization, pre-requisite learning elements, spatial perception ability and learning how to draw phases. It is needed to analyze related subordinate concepts accurately, to investigate and supplement them before the original instructions, and to grope for a plan which grasps related misconceptions and deals with them during instructions (Diakidoy, Vosniadou and Hawks, 1997; Vosniadou and Brewer, 1994). Myeong (2001) said that the reason why the preliminary teachers failed solving the problem of the moon and planets was that they had not learned how to draw the phases. She (Myeong, 2001) emphasized the necessity of learning how to draw them. The spatial perception ability may be applied to the problem-solving procedure. The reason is that an observer watches the

*Corresponding author: earth214@hanmail.net
Tel: 82-51-510-2707
Fax: 82-51-513-7495

lateral side of the planet when he observes it though the plane figure is used to show a heavenly body's position relation in the case of drawing the phases. The principle which is applied for solving the problem of the lunar phases changes is identically applied for the planetary phases change. Thus, it is necessary to develop teaching-learning materials that help understand the principle of drawing the phases changes and generalize it.

Therefor, this research has two objectives. One is to develop a module drawing phases with which learners can understand the concepts of the lunar and planetary phases easily. The other is to verify the effects of learners' conceptual change and achievement through instructions using this module.

Conceptual change means the state of learners' concept changes. Conceptual change in this study is designated that misconceptions are changed into scientific concepts and placed in learners' cognitive structures. In order to check conceptual change, paper-based evaluations using conceptual inspection test and individual interviews are administered before and after instruction. The achievement is measured by the multiple-choice test to study whether the students know the lunar and planetary phases in relationships with the position of the Moon, the Sun, and the Earth. Even though the students have difficulties with the concept of phases change, they can solve the problems. This research questions are as follows.

First, does the instruction using the module drawing the lunar and planetary phases affect learners' conceptual change and achievement ?

Second, is the effects of instruction using the module different according to the learners' characteristics (spatial perception, required pre-requested learning elements, science inquiry ability)?

Development of Module

The simplifying conditions method (SCM) was used as a task analysis in this research. It is a method of task analysis and sequence which is based on the elaboration theory of Reigeluth (1979). SCM analyses the task with finding conditions which simplify the given task, or uses the conditions for simplifying and achieves elaborate sequence gradually. SCM characterizes reality and that guidelines are prepared to the users.

It is the most important thing in the procedure of the task analysis to find out an epitome. First of all, the various types of tasks which are involved in the lunar and planetary phases change are as follows; the lunar phases seen from the Earth, the inner planetary phases seen from the Earth, the outer planetary phases seen from the Earth, the earth's phases seen from the Moon, and any planetary phases seen from a specific position of the universe space. The reasons why students think it is difficult to understand this concept are as follows.

Firstly, the Moon and planets do not light themselves but reflect the received lights. And the shape of the Moon and planets is a round sphere. It is difficult for a sphere to be distinguished the front and the back, the left and the right. The material for the problem-solving situation is the picture of position relations. It is difficult to understand the concept of the size of the phases' angle. Position relations are changed continuously by the motion of celestial bodies. It is difficult to understand when supposing an observer is located at other planet, not from the Earth. It is necessary to have spatial perception ability especially to solve these problems.

I simplified this problem which is difficult with the following solution. The problem caused by the sphere are around was solved by numbering from 1 to 8 on the sides of a basketball, as Figure 1. By using the basketball that is very familiar, it is easy for students to approach the task. Understanding the picture of position relations was achieved through practice of drawing a plane Figure. Students were firstly allowed to think the source of light exists on the left side or the right side of an object which will be observed. The epitome made through these approaches is to draw the plane fig-

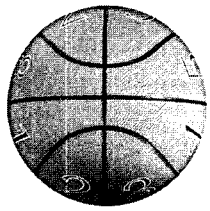


Fig. 1. The baseball used this module.

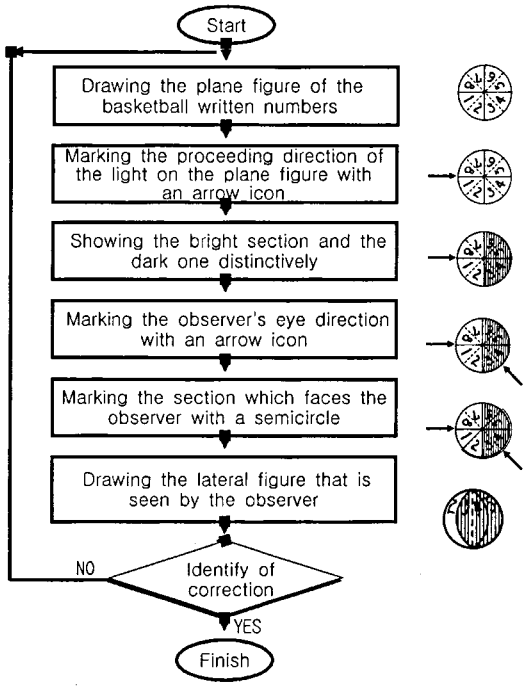
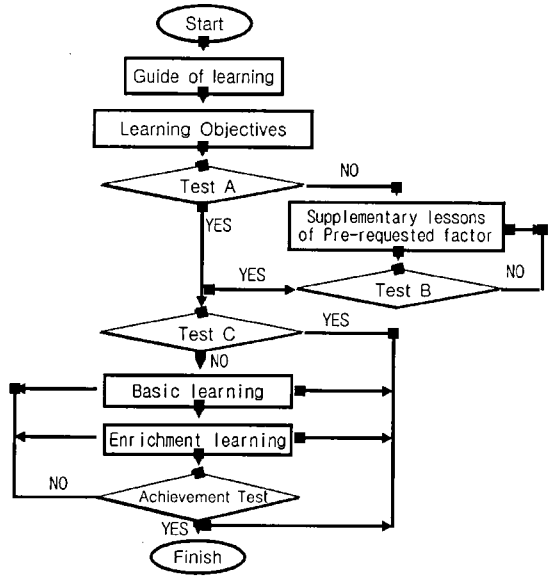


Fig. 2. The procedure to perform the epitome.

Table 1. The elaboration procedure

Step	Contents of task
1	The epitome
2	Draw the lunar phases seen in the earth
3	Draw the inner planetary phases seen in the earth
4	Draw the outer planetary phases seen in the earth
5	Draw the earth's phases seen in the moon
6	Draw any planetary phases seen at a specific position of the universe space



Test A: Diagnostic test of pre-requested learning factor
Test B: Post-test of pre-requested learning factor
Test C: Pre-test of learning ability

Fig. 3. The procedure of using this module.

ure and the lateral figure of the basketball which was divided into eight parts. The procedure to perform this epitome is shown by Fig. 2.

The elaboration procedure is, as seen in Table 1, to seize the epitome, add the simplified condition one by one and construct the contents step by step elaborately and complicatedly.

The first stage is the epitome. Next, draw the lunar phases seen from the Earth. Next, draw the inner planetary phases seen from the Earth. The size of the planet is different depending on the distance. Next, draw the outer planetary phases seen from the Earth. Next, draw the earth's phases seen from the Moon. This is the most difficult task for students. The reason is that the position of the observer changes the Moon. Finally, draw any planetary phases seen at a specific position of the universe space.

Figure 3 is a flow chart that represents the strategy which the developed instruction module is applied to the instruction.

The learners who have already understood the contents to learn through the diagnostic test of prerequisite learning factor don't need to take the original instruction and complete the learning and practice the deeper study or the next-step study. If they have a wrong question-item, the learners should go

to study the learning task for solving the item and move on the next step. If there are the parts that they don't reach learning objectives as a result of an after-activity achievement test, they may go to study the relevant learning task and move the next step.

Methodology

The distinctive feature of this research method is to apply the designs of sequential mixed method that are added to the qualitative research in order to investigate the effects of instruction using the developed module. The qualitative research method was operated to verify the effects of the developed module and it in accordance with learners' characteristic. The quantitative research method was operated to verify learners' conceptual changes before and after the instructions using the developed module.

As the conceptual changes occurs to learners' cognitive structure, an interview method may be appropriate to check the degree of understanding. This study consists of two parts. The one is to verify the effect of the developed module and the other is to verify the effect of it according to learners' characteristic after the quantitative research. The reason why the quantitative researche operated, is to remove the possibility of which the field research's result may generally have some influences on students' academic scores in school.

The first research: It was operated from the second week of May, 2001 to the second week of July, 2001. The subjects were 270 male students attended K high school in Gyeongnam Korea. Homogeneous experimental groups of 135 students in the three classes and control groups of 135 students in the other three classes were selected as a result of a pre-test. The experiment was designed as Fig. 4. Pre-test and post-test for conceptual change is the same type test which consists of 12 question items as seen in Table 2.

$$\begin{array}{ccc} O_1 & X_1 & O_2 \\ O_3 & & O_4 \end{array}$$

O_1: pre-test of experimental groups
O_3: pre-test of control groups
X_1: instruction using the module
O_2: post-test of experimental groups
O_4: post-test of control groups

Fig. 4. The first experimental design.

All answers regard as correct if both answers and the reason of choosing the answers are right. And the perfect score is 6 points. It was developed by a researcher and 3 earth science educators. And its content validity was verified by 5 science educators. Its reliability is Cronbach $\alpha = .83$. Pre-test and post-test for achievement is also the same type test which consists of 20 question items as seen in Table 3.

The achievement test, i.e., a multiple chose test, is to check out how much students understand lunar and planetary phases. The perfect score is 20 points. Its reliability is Cronbach $\alpha = .86$ and .85 respectively.

The experimental group was studied using this module and, for the control group, general instruction method using the textbook was used. The instructions were guided by the same teacher and performed one hour per week for five weeks. In

Table 2. List of questions on conceptual change test

Question	Contents
Q 1, 2	Explaining the brightness of the full Moon when the Sun disappears
Q 3, 4	The reason of Lunar phases change
Q 5, 6	Finding the position that we cannot see the Moon
Q 7, 8	Finding the position that is a gibbous Moon
Q 9, 10	Finding the area of the Moon that we can see in the plane figure
Q 11, 12	The phase of Earth shown in the full Moon

Table 3. List of questions on achievement test

Question	Contents
Q 1	The position relationship that is a new Moon
Q 2, 3, 4	The phase of Moon in the position relationship
Q 5, 6, 7, 8	The phase of Venus in the position relationship
Q 9	The phase of Moon and Venus in the position relationship
Q 10, 11, 12	The phase of Moon and Mars in the position relationship
Q 13, 14	The phase of Earth shown from the Moon
Q 15	The phase of Earth shown from the gibbous
Q 16	The phase of Earth shown from the new Moon
Q 17, 18, 19, 20	The phase of planet shown from the special position

analyzing data, the t-test of SPSS 10.0, a statistics package program, was used.

The second research: It was investigating the effects of the learners' characteristic on the conceptual change and accomplishment. It was operated from the first week of September, 2001 to the first week of November, 2001. The interview for the qualitative research was done together. The subjects were 270 male students attended K high school in Busan, Korea. They had been taking Earth science . The experiment planning belongs to the one group pre-test and post-test design as seen in Fig. 5.

The tests for spatial perception (Hwang, 1994), logical thinking (GALT; Roadrangka and Padilla, 1983), science inquiry ability (TIPS; Burns et al., 1983) and required pre-requisite learning elements made to investigate learners' characteristics. Tests of conceptual change and achievement operated before and after instructions. The treatment and analysis of data were used with SPSS 10.0. The

$$O_1 \quad X_1 \quad O_2 \quad O_3 \quad X_2 \quad O_4 \quad O_5 \quad O_6$$

O_1: pre-test (concept and achievement)
X_1: learning of pre-requested learning element
O_2: test of pre-requested learning element
O_3: interview A
X_2: instruction using Module
O_4: post-test (concept and achievement)
O_5: interview B
O_6: long term-retention test (after 2 months)

Fig. 5. The second experimental design.

main effects and interactive effects were surveyed with the two way ANOVA analysis between the learners' characteristics about conceptual change and achievement score and the time of tests.

Results and Discussion

The Result of the First Research

As seen in Table 4 and 5, the results of the first research revealed that the effects of the instruction using the developed module on conceptual change

Table 4. The result of *t* test about the conceptual change in the post-test

Groups	N	M	SD	t	p
Control	135	3.90	1.59	5.913	.000
Experimental	135	4.95	1.29		

*p< .05

Table 5. The result of *t* test about the achievement in post-test

Groups	N	M	SD	t	p
Control	135	14.01	3.68	9.344	.000
Experimental	135	17.63	2.60		

*p< .05

Table 6. Analysis of variance of the conceptual change by learners' levels of spatial perception ability

SV	SS	df	MS	F	p
Between groups (A)	201.202	2	100.601	29.216	.000
Within groups (B)	423.119	1	423.119	360.589	.000
A × B	1.581	2	.791	.674	.511

Table 7. The score of the conceptual change by the levels of spatial perception ability

	High level (N = 90)		Middle level (N = 90)		Low level (N = 90)	
	pre-test	post-test	pre-test	post-test	pre-test	post-test
M	3.41	4.67	2.24	4.44	1.73	3.69
SD	1.32	0.95	1.51	1.35	1.29	1.54

Table 8. Analysis of variance of the conceptual change by learners' levels of science inquiry ability

SV	SS	df	MS	F	p
Between groups (A)	168.669	2	84.334	23.655	.000
Within groups (B)	424.698	1	424.698	371.786	.000
A × B	9.882	2	4.941	4.326	.014

Table 9. The score of the conceptual change by the levels of science inquiry ability

	High level (N = 91)		Middle level (N = 88)		Low level (N = 91)	
	pre-test	post-test	pre-test	post-test	pre-test	post-test
M	3.04	4.71	2.17	4.59	1.71	3.70
SD	1.66	1.22	1.49	1.26	1.25	1.51

and achievement have meaningful difference at level of 5%.

Scores of the experiment group's conceptual change and achievement was higher than ones of the control group's. This can be regarded as the effect of the instruction applying the module. The instruction of the module drawing the lunar and planetary phases enables learners to elicit existing misconceptions, to induce meaningful conflicts, and to change them into scientific concepts.

The Result of the Second Research

The first research clarifies that the instruction using the module is more effective for learners' conceptual change and the degree of achievement than general instructions which don't use it. Thus, the second research looked into the difference in effects in accordance with learners' characteristic. The second research to investigate the difference in the effects which may be different according to learners' characteristic looked into the interactive effect differ from learners' characteristic.

Conceptual Change Affected by Learners' Characteristics

As seen in Table 6 and 7, learners' levels of spatial perception ability affects the conceptual change. In the following Tables shown the analysis of variance, *SV* means a source of variance, *SS*, within group sum of squares, *MS*, mean square within, and *df*, degree of freedom. There was no difference between learners' levels of spatial perception ability. As seen in Table 8 and 9, learners' levels of science inquiry ability affected the conceptual change. There was a significant difference between learners' levels of science inquiry ability. The students who had the middle level of science inquiry ability had a highly influence.

As seen in Table 10 and 11, learners' levels of required pre-requisite learning ability affects the

Table 10. Analysis of variance of the conceptual change by learners' levels of pre-requested learning ability

SV	SS	df	MS	F	p
Between groups (A)	213.458	2	106.729	31.415	.000
Within groups (B)	422.014	1	422.014	367.821	.000
A × B	8.543	2	4.272	3.723	.025

Table 11. The score of the conceptual change by the levels of science inquiry ability

	High level (N = 92)		Middle level (N = 82)		Low level (N = 96)	
	pre-test	post-test	pre-test	post-test	pre-test	post-test
M	2.31	4.84	2.22	4.39	1.56	3.80
SD	1.57	1.16	1.47	1.33	1.21	1.51

Table 12. Analysis of variance of the achievement by learners' levels of spatial perception ability

SV	SS	df	MS	F	p
Between groups (A)	4775.988	2	2387.994	133.201	.000
Within groups (B)	5270.313	1	5270.313	604.466	.000
A × B	108.226	2	54.113	6.206	.002

Table 13. The score of the achievement by the levels of spatial perception ability

	High level (N = 90)		Middle level (N = 90)		Low level (N = 90)	
	pre-test	post-test	pre-test	post-test	pre-test	post-test
M	11.60	18.49	9.22	17.68	6.56	12.68
SD	4.37	1.33	4.07	1.73	3.38	3.41

Table 14. Analysis of variance of the achievement by learners' levels of science inquiry ability

SV	SS	df	MS	F	p
Between groups (A)	1557.289	2	778.645	25.970	.000
Within groups (B)	5269.874	1	5269.874	577.746	.000
A × B	.764	2	.382	.042	.959

Table 15. The score of the achievement by the levels of science inquiry ability

	High level (N = 91)		Middle level (N = 88)		Low level (N = 91)	
	pre-test	post-test	pre-test	post-test	pre-test	post-test
M	10.81	17.68	9.36	16.50	7.21	14.67
SD	4.48	2.19	4.18	3.41	3.97	3.92

conceptual change. There was a difference according to learners' levels of pre-requisite learning ability. The instruction using module affected the students who had the middle and low level of it more effectively.

Achievement Affected by Learners' Characteristics

As seen in Table 12 and 13, learners' levels of spatial perception ability affected the achievement.

There was a difference of achievement in accordance with learners' levels of spatial perception ability. The module affected the middle level students more effectively. As seen in Table 14 and 15, learners' levels of science inquiry ability affects the achievement.

There was no difference of achievement according to levels of science inquiry ability and pre-req-

Table 16. Analysis of variance of the achievement by learners' levels of pre-requested learning ability

SV	SS	df	MS	F	p
Between groups (A)	2690.176	2	1345.088	52.257	.000
Within groups (B)	5267.614	1	5267.614	584.359	.000
A×B	29.358	2	14.679	1.628	.198

Table 17. The score of the achievement by the levels of pre-requested learning ability

	High level ($N=92$)		Middle level ($N=82$)		Low level ($N=96$)	
	pre-test	post-test	pre-test	post-test	pre-test	post-test
M	11.71	17.79	9.34	16.73	6.47	14.45
SD	4.64	2.62	3.90	3.10	3.00	3.68

uisite learning elements.

As seen in Table 16 and 17, learners' levels of pre-requisite learning ability affected the achievement.

The level of pre-requisite learning ability had no effect on the students' achievement. The instruction of the module drawing the Lunar and planetary phases enables learners to elicit misconceptions, to induce meaningful conflicts, and to change them into scientific concepts.

The students with the high level of the spacial perception ability showed the high ability to solve given problem and to reconstruct the problem. The degree of the achievement was affected by spacial perception ability regardless of the levels of science inquiry ability. The degree of achievement was also affected, regardless of the levels of required pre-requisite learning ability. The better spatial perception ability they have, the better scientific concept they acquire and maintain. Students who did not change the misconceptions into the scientific concepts accepted only some parts of the scientific concepts. They, however, seemed to have difficulty in combining their concepts with all the concepts needed to understand the lunar and planetary phases change. Especially, the lower spatial perception ability they have, the more difficultly they had in changing the misconception into the scientific concept. Even after the instruction, they seemed to perceive the misconceptions as a scientific conception. Students with constituted the scientific concept seem to receive the concept conflict due to the developed module. Their response after the instruction showed that it is changing more scientific concept and maybe the module also led to the students' conceptual change.

Conclusion

The objectives of this paper were to develop a phase drawing module which helps learners easily understand the concepts of the lunar and planetary phases and to verify the effect of the instruction using this module on learners' conceptual change and achievement.

In order to accomplish these research objectives, the learning task was analyzed and a drawing module of the lunar and planetary phase change was developed according to the module developing procedure. Then, the module was applied to the instruction for second-grade students at a high school in Busan, Korea and the effect was examined.

The conclusion of this study is as follows. First, in order to assess the effect of the lunar and planetary phase drawing module, instruction using the module and traditional instruction were held, and then, tests for assessing learners' conceptual change and achievement were administerd. Results showed that the instruction using the module was effective improving learners' conceptual change and achievement

Second, it was investigated if the effect of instruction using the module varied with the learn-

ers' characteristics. The result showed that, in terms of the learners' conceptual change, whereas the effect of instruction with the module did not vary with learners' spatial perception ability, the effect did vary with science inquiry ability and required pre-requisite learning ability. Especially, for students who are classified into the middle level in science inquiry ability and students in the middle or low level in required pre-requisite learning ability, the instruction with the module was largely effective. In terms of learners' achievement, the effect of the instruction with the module varied with spatial perception ability, while the effect did not vary with science inquiry ability and required pre-requisite learning ability. Particularly, for students who are classified into the middle level in spacial perception ability, the instruction using the module was largely effective.

It was evident that not all students understood the scientific concepts contained in the instruction with the module. Even the excellent learning materials cannot be effective to every learner. Therefore, considering learners' characteristics and learning style, adequate learning materials and the strategies for the conceptual change should be developed and provided.

References

Burns, J.C., Okey, J.R., and Wise, K.C., 1983, Integrated Process Skills Test II. Georgia: Department of Science Education, University of Georgia.

Diakidoy, I., Vosniadou, S. and Hawks, J.D., 1997, Conceptual change in astronomy: Models of the Earth and the day/night cycle on American-Indian children. European Journal of Psychology of Education, 12(2), 159-184.

Driver, R., Guesne, E., and Tiberghien, A., 1985, Children's ideas in Science. London: Open University Press.

Gilbert, J.K. and Swift, D.J., 1985, Towards a Lakatosian analysis of the Piagetian and alternative conceptions research programs. Science Education, 69(5), 681-696.

Hwang, J.K., 1994, The Outline of Operating the comprehensive IQ Tests (for junior and senior high school students). Association for Principals of Korean Private Junior and Senior High School.

Myeong Jeonok, 2001, Reasons for Unsuccessful Earth Science Problem Solving of Pre-service Teacher: A study on the Motions of the Moon and the planets, Jour. Earth Science Society, v. 22 no. 5, 339-349.

Nussbaum, J. and Sharoni-Dagan, N., 1983, Changes in second grade children's preconceptions about the earth: As a cosmic body resulting from a short series of audio-tutorial lessons. Science Education, 67(1), 99-114.

Reigeluth, C.M., 1979, In a search of a better way to organize instruction. The elaboration theory, Journal of Instructional Development, Vol. 2(3).

Roadrangka, V. and Padilla, M.J., 1983, The construction and validation of GALT. Paper presented at the annual meeting of the National Association for Research in Science Teaching, Dallas, Texas.

Vosniadou, S. and Brewer, W.F., 1994, Mental models of the day/night cycle. Cognitive Science, 18, 123-183.

Manuscript received, January 16, 2004
Revised manuscript received, March 18, 2004
Manuscript accepted, March 25, 2004