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Abstract: Until recently, common instructional strategies and materials in the Korean middle school science classes have been primarily designed on the basis of learning models implied in behavioral psychology. As well known, behavioral psychology is the counterpart of various forms of positivistic epistemology(Margolis, 1984). Positivism implicitly suggests that scientific knowledge can be transmitted as it is from the cognitively systematized head of teacher to the undifferentiated or tabula rasa head of learner. In accordance with this tacit assumption, behavioral psychologists have proposed a mastery teaching model which consists of three general steps of instruction as follows: informing students the materials to be taught, verification of the information by the students through observation, and application of the knowledge acquired (Cosgrove & Osborne, 1985). Called conceptual formation and/or differentiation model by Ausubel et al.(1978), this teaching process presupposes that systematic lecture is one of the most usable teaching strategies in any science class and under any learning circumstance.

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The Effects of Instructional Strategies on Conceptual Exchange and Differentiation

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INTRODUCTION

Until recently, common instructional strategies and materials in the Korean middle school science classes have been primarily designed on the basis of learning models implied in behavioral psychology. As well known, behavioral psychology is the counterpart of various forms of positivistic epistemology(Margolis, 1984). Positivism implicitly suggests that scientific knowledge can be transmitted as it is from the cognitively systematized head of teacher to the undifferentiated or tabula rasa head of learner. In accordance with this tacit assumption, behavioral psychologists have proposed a mastery teaching model which consists of three general steps of instruction as follows: informing students the materials to be taught, verification of the information by the students through observation, and application of the knowledge acquired (Cosgrove & Osborne, 1985). Called conceptual formation and/or differentiation model by Ausubel et al.(1978), this teaching process presupposes that systematic lecture is one of the most usable teaching strategies in any science class and under any learning circumstance.

Nowadays, a variety of teaching strategies including this traditional model is being practiced in the Korean secondary school science classes. Among them, the most seriously concerned instructional model has been structured with a psychological view of constructivism for its theoretical background. Based on the epistemological position of post-positivism, constructivists commonly interpret learning of science as an adaptive process through which learner's conceptual frameworks are progressively reconstructed. They infer from this interpretation that students can be in continually keeping up with a wider range of experiences and new ideas through the learning process. They also see learning as an operative conduct of sense making over which the learners can control(Driver, 1983).

Most of the Korean science educators have inclined to develop the instructional strategies and materials on the ground of those new psychological-epistemological perspectives. They have endeavored to develop teaching models based mainly on the supposition that learners' preconceptions are changed through the interactions with learning environment. However, it has not been confirmed up to the present that the constructivist models exert universal effects on all sort of the scientific concepts with different structure. This problem has been clearly recognized by Millar(1989) when he argues that the constructivist models of learning are rather associated with a particular model of instruction. In the meantime, science educators have reached an epistemological consensus about content-and/or context-dependence of conceptual change process. Most science educators contend that learning process on the part of students is usually dependent on the nature of content and/or the contexts of teaching material. This implication has been substantiated by the fact that constructivists' models have resulted in the positive effect only on the scientific concepts which are theoretical or abstract in their intrinsic nature.

The main goal of this research was to examine the potential effects of two instructional models on the different types of scientific concepts. In order to achieve this goal, an instructional model was built on the new psychological-epistemological perspective that learners' conceptions are changed through the selected learning process. Along with the traditional model, this new instructional model was employed in the development of teaching/learning strategies and materials for the unit of "the motions of molecules" and "processes of rocks formation and their characteristics".

METHODS AND PROCEDURES

The central methodological features of this study were threefold: to identify the misconceptions related to the topics selected for this study; to build teaching strategies and materials for the topics with reference to the misconceptions identified at the first stage; and to determine any instructional efficiency of the teaching strategies and materials by putting them into the real science classes. The study was performed in a two-year period of 1990-1991. Three middle school science teachers participated in the study and assisted the author to develop the instructional strategies and materials. They used the strategies and materials in their science classes as well.

The sample consisted of 750 second grade(aged 13-14) students(of 15 intact classes).

They were selected from three middle schools(five classes from each school). The schools are located in a small city with a population of about 160,000 inhabitants. But the SES of the students was heterogeneous with various socioeconomic backgrounds. Before teaching strategies and materials were administered, the sample students were divided in terms of intact class as unit into two groups: control and experimental group.

Misconceptions were identified both through analysis of the previous research and by the use of two tier paper and pencil test. Two tier test items were developed in conformity to diagnostic test method suggested by Treagust(1988). He proposed the method as an effective tool for evaluating students' misconceptions. The paper and pencil test items were devised by the author with assistance of three science teachers participated in this study. The test items were composed of 11 and 12 questions as they were related to the molecular motions and rock formations, respectively.

The test instruments were administered to the real classes selecore the instructional strategies and materials were put into practice. No time limit was set for students to complete the problems. Most of the pupils completed all the test items within 30 minutes. The content validity of the items was insured by basing their construction on the list of concepts contained in the 5th National Curriculum which was reformed in 1987 by the Korean Ministry of Education.

The instructional materials were developed for the units of two concepts: the motions of molecules; processes of rocks formation and their characteristics. These concepts were chosen because they had been importantly treated in the science textbooks used by the second grade students of Korean middle schools and, furthermore, the concepts were significantly different from each other in the abstractiveness and conceptual structures. The former concept is intrinsically theoretical and abstract in contrast with the latter one which is comparatively conceptual and concrete in essence. However, the teaching materials for both the topics were developed on the basis of the same instructional model.

The instructional materials for chemistry topic were administered in May of 1990 and earth science topic in June of the same year. Two science teachers used the materials following the normal curricular courses at their schools. According to participating teachers, both topics have been usually taught stretching a four school hours. But the materials were practiced over a three-instructional-hour period.

The teaching strategies and materials developed on the basis of constructivist standpoint were administered to experimental classes and traditional ones to control classes. Then, the efficiencies of the teaching strategies and materials were determined by comparing the achievement levels of two groups. SPSS subprogram ANOVA was utilized in analyzing achievement levels.

RESULTS AND DISCUSSIONS

This part summarizes the results of the research carried out to investigate differences of instructional effects between two types of teaching strategies. As indicated at the beginning, one reason to accomplish this kind of study is that science educators have been exhibiting a tendency to overemphasize the constructivism based teaching strategies and, at the same time, neglect the traditional teaching methods. The results are discussed in order that the study went through.

Investigation of Misconceptions

The students' ideas were assessed via an objective paper and pencil test method. Misconceptions identified by using the instrument are as follows:

Volume of a matter decreases as its mass decreases

Quality of a matter decreases as its weight decreases

Pressure exerts its effects in the direction of force

Volumes of liquids do not decrease even if pressure increases

If air is compressed, particles make lumps

Air is made of particulate lumps

This list of students' conceptions does not greatly vary from one made by other researchers. Misconceptions found by the previous research can be summarized as follows:

Every substance tends to move towards its natural place(Nussbaum, 1985)

Vacuum is impossible(Nussbaum, 1985)

Matter is continuous(Doran, 1972; Driver, 1983; Nussbaum, 1985)

There is no spacing between the particles of mat- ter(Doran, 1972)

The particles of matter do not move(Doran, 1972)

The spacing and speed of particles of matter are unrelated to the temperature and phase of the matter(Doran, 1972)

Development of Instructional Strategies

The instructional strategies and materials were developed by the use of CLISP's teaching model. Supporting constructivist pedagogy to learning as conceptual change, Driver and Oldham(1986) suggested a teaching sequence comprising five phases: orientation, elicitation, restructuring, application and review. This sequence runs parallel to the steps of instructional strategies and teaching materials developed in this study. As a matter of fact, the sequence is composed of such five steps as orientation towards learning context and problem situations, identification of preconceptions and understanding each other's conceptions, restructuring of preconceptions, problem solving and application, and evaluation.

The first step of the study was designed to direct students towards the learning context and introduce them to the topic to be learned. Then students were given problems which can't easily be solved by using previously learned knowledge. In consequence of the problem solving process, students could have an opportunity to develop a sense of learning purpose. In this step, teachers endeavored to use particularly familiar terms with students in describing the topic and in presenting the problem.

This step was followed by a identifying and communicating process. Students were asked to clarify their own conceptions and solve the problems through discussion. They could communicate with each other in a group of 6 or 7. After group discussion, students were moved to class discussion through which each group or individual could clarify further their own ideas.

In the third step, teachers defined the concepts which were considered important and related to the phenomena and problems presented. Once teachers explained the meanings of the concepts, students had opportunities to compare their conceptions with the meaning presented by the teachers. If necessary, students differentiated their conceptions or exchanged with the teachers' concepts.

In the problem solving and application step, students explained the phenomena and solved the problems by the use of their new conceptions. They also compared their new conceptions with old preconceptions by themselves. If they could have not explained the phenomena nor solved the problems, teachers explained the core instructional content again.

In the final evaluation step, students were given chances to apply their new knowledge to a variety of new contexts. Through this process, students were expected to reflect their own problem solving process and differentiate further their new conceptions. After students examined their own learning processes and new meanings of their conceptions, teachers evaluated students' ability to apply new knowledge to diverse problems in various ways.

Effects of Teaching Strategies and Materials

Table 1 summarizes the results of an ANOVA done in order to compare the experimental and control groups' achievement levels for the unit of "the motions of molecules". As described in Table 1, there is a significant difference between the achievement levels. The results show that the teaching strategies and materials developed in this study produced remarkable effects on the students' achievement.

Table 1. Achievement Levels in Chemistry Topic

school	groups	n	pre–test	post–test	MD**
A	control	142(3)*	14.20	18.35	4.15
	experimental	143(3)	13.74	18.76	5.01
	P		0.438	0.352	0.077
B	control	100(2)	13.84	17.07	3.23
	experimental	99(2)	13.98	20.25	6.27
	P		0.626	0.004	0.000

* number of classes ** mean difference

Table 1 demonstrates that there was no significant differences between the scores of pre- and post-test at both schools. However, it was found that means of the difference scores of the students in the experimental group were significantly higher than those of the students in the control group.

These trends are contrasted with the case of the earth science subjects. Table 2 describes the results of ANOVA performed in the interests of investigating any difference between the experimental and control groups' scores on the achievement test.

Table 2. Achievement levels in Earth Science Topic

school	classes	n	pre–test	post–test	MD
A	control	144(3)	11.14	15.13	3.99
	experimental	146(3)	11.45	14.77	3.33
	P		0.517	0.526	0.106
B	control	102(2)	13.19	14.29	1.11
	experimental	101(2)	11.89	14.81	2.92
	P		0.032	0.457	0.001

As shown in table 2, it is hardly clear that differences in the achievement levels are significant. When two schools' data were collapsed, the significant level was further decreased(p=0.277). There might be several reasons for this outcomes. Teachers' major specialties and teaching experiences may be included among the reasons. School A teacher majored in chemistry and, as of the time this research was in process, had two years' teaching experiences. On the other hand, school B teacher with ten years' teaching experiences had made a special study of earth science.

IMPLICATION FOR SCIENCE TEACHING

This study has practical implication for science teachers, because it provides them with effective teaching strategies and materials. They can even use the traditional teaching methods with mind at ease depending on the subjects to teach. Most of the recent research on misconceptions have tended to emphasize the conceptual change model of teaching. However, this study demonstrated that the traditional teaching model, i.e. conceptual formation and/or differentiation can be still used as an effective instructional tool in science education.

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