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Gifted Students Understanding of Science Concepts through Activities of Modifying of Scientific Conceptual Models

Jung Kuk Kim, Seong Oh Jeong, and Young Min Kim
Pusan National University, Busan, 609-735, Korea

[redacted]

The concern with scientific models has been growing in science education, and schematic models are frequently used to teach science concepts in secondary schools. The aim of this study is to investigate how well the scientifically gifted students understand scientific concepts through activities of modifying scientific models which we developed. Thirty 8th-grade students participated in the study, 15 in a control group and 15 in an experimental group. For the students in the experimental group, teaching material with activities of modifying models, while for the students in the control group, the teaching material with traditional activities such as explanation, problem solving, and reading. The teaching contents in physics for both groups were linear momentum. We used multiple-choice test and essay-type test to evaluate students' achievements after lessons, and then compared their achievements of both groups. Through the research, we could find a clue that model-modifying activities are helpful for the gifted students to enhance their understanding of physics concepts, although the statistics does not show meaningful difference between experimental and control groups.

I. INTRODUCTION

Scientific model is a representation of structure in a scientific knowledge system and its properties. The scientific models are very important in having knowledge about science concepts. Gilbert (1993) insisted that models are major teaching and learning tools in science education, and Hestenes (1997) insisted that understanding scientific concepts emerges from using scientific models and scientific instruction should be designed to engage students in making and using models. Therefore, there are many scientific models in science textbooks for explaining science concepts, and science teachers have used those models for teaching science concepts effectively. Nevertheless, most of students have concerns just only about memorizing of summarized knowledges without understanding of a structure and properties of the concept. Many students don't concentrate on the scientific models when learning of scientific knowledge from science textbooks.

Over the last four decades, many researches about various methods of using scientific models as well as simple analyzing of scientific models in science teaching have been studied. Some studies (Cohen & Murphy, 1984; Osborne & Gilbert, 1979; Halloun & Hestenes, 1985) just only defined about model of concept, and investigated scientific models in science teaching or common sense concepts about motion for teaching physics using models, while other studies have been researched about modelling (Halloun, 1990; Gilbert, 1993), constructing of mental model (Chiu, et. al., 2002), and model building activity (Halloun, 1990; Rouwette, et. al., 2002). Halloun (1990) developed schematic models for teaching mechanics effectively, and Rouwette, et. al (2002) applied the method of group model building and analyzed the effectiveness of it.

But, above methods using models for teaching and learning for science is difficult and may take long time for middle school students, even though they are science high-achievers. They need simpler methods for learning science using scientific conceptual models. Our idea for teaching and learning science is related about how to make students to concentrate on scientific conceptual models and understand them without using the method of model building activity when learning science from science textbooks. One method is to manipulate with the given scientific conceptual models by themselves. Therefore, we devised the model modifying activities, which students themselves modify the scientific models given by science teachers or in science textbooks according to their own ideas after being taught such science concepts, as a learning activity of science concepts, assuming they may concentrate on the given scientific conceptual models. Therefore the purpose of this study is to investigate if Modifying Activities of Scientific Models help students achievements in science learning, particularly in physics learning.

II. RESEARCH PROBLEM and METHOD

Research Problem

Is the achievement of the gifted and talented students learned physical concepts through Modifying Activities of Scientific Conceptual Models higher than that of the gifted and talented students learned same concepts through the traditional method? Here, the traditional method means learning by mainly listening of lectures and reading textbook.

Sampling of Subjects

Thirty 8th-grade students were sampled from an Education Center for The Gifted and Talented in Korea. They are high-achievers in science test which are administerd by City Board of Education. They were divided into two groups, a control group(CG) of 15 students (10 males and 5 females) and an experimental group (EG) of 15 students (9 males and 6 females). To the control group, traditional instructions were implemented, and to the experimental group the instructions with Modifying Activities of Scientific Conceptual Models were implemented.

Achievement Test Tools

We developed pre- and post-test tools, which includes 8 questions, respectively. The questions are related to linear momentum, impulse, and conservation of momentum, they are composed of four Multiple-choice and explanation type test problems and four Essay type test problems. The test tools were revised and completed through three times of discussion among a seminar group of graduate physics education consisted of two professors of science education and six teachers having Ph.D or master degree of science education. Table 1 shows of examples of Multiple-choice and explanation type test and Essay type test problems.

Table 1. Examples of Multiple-choice and explanation type and Essay type tests

	Test Question
Multiple-choice and explanation type test	If a force of 5 N acts on object for 3 s, what is the change in momentum of the object? Why do you think so? (a) 5/3 (b) 2 (c) 8 (d) 15
Essay type test	If linear collision occurs between the two objects with unknown masses and velocities, but with same direction, in which conditions are the directions of the objects opposite after collision?

In the multiple-choice and explanation type test, if student answers correctly to both of multiple-choice and explanation questions, he/she gets 10 points, while he/she gets only 5 points if answers correctly to only multiple-choice question. In essay typed test, if student give correct answer and correct process for getting answer, he/she gets 15 points, if he/she gives correct answer and insufficient correct process, he/she gets 10 points, if he/she gives correct answer only or gives correct answer with incorrect process, he/she gets only 5 points.

Modifying Activity of Scientific Conceptual Model and Evaluation

For the study, we developed Modifying Activities of Scientific Conceptual Models, which have processes of consideration, modification, and validation of scientific model by students themselves. The activity tasks are composed of two tasks using mathematical models and three tasks using schematic models, which are commonly used in physics textbook of high school in Korea. The reason why the activity contents are form high-school physics textbooks is that the students sampled studied already all the contents of middle school science textbook. Each task has three steps of considering a given scientific model, modifying of it, and explaining the reason of modifying it. In the step of considering a given model, students examine the diagram and terminologies in the model, and compare with their own conceptions taught from a science class teacher. In the step of modifying of a given model, students may modify the diagram or terminologies in the model according to their own ideas. And in last step, students give a reason why the given model should be modified, scientifically. Fig. 1 shows an example of worksheet for modifying activity of a scientific conceptual model. Sometimes, they do not modify the models, but during examining them to modify, they concentrate and understand the meanings implicated in the scientific conceptual models.

<table>
<tr><td colspan="3">Modifying of Model Worksheet 3 (time limit [illegible])
▶ Identification number : Name :</td></tr>
<tr><td>Scientific Conceptual Model in Science Textbook</td><td colspan="2">

운동량 mv_1 + 충격량 $F\Delta t$ = 운동량 mv_2
▶ Physical concept : "Impulse is equal to the change of momentum"</td></tr>
<tr><td>Is there anything that you want to modify in the model? Which ones?</td><td colspan="2"></td></tr>
<tr><td rowspan="2">Modify as you want, and give reason(s) why you modify it.</td><td>Model you modified</td><td></td></tr>
<tr><td>Reason(s) of modifying</td><td></td></tr>
</table>

[Fig. 1.] An Example of modifying of model worksheets

The modified models show us how they understand the models, and what aspects of the models they concentrate, and in which concepts they have misconceptions. Their modified models were evaluated by three criteria such as implication, accuracy, and validity of reason, which is shown in table 1.

Table 1. The Criteria of Evaluation of a Modified Model

[illegible]		Implication*	Accuracy**	Validity of Reason***
Points	High	3	3	3
	Middle	2	2	2
	Low	1	1	1

* The level of information explained in a modified model
** The accuracy and adequacy of a modified model
*** The level of validity of the reason for modifying a model.

III. RESEARCH RESULTS

Pretest Results

Table 2 shows the means of achievement in pretest of two groups. The means of achievement of experimental and control groups are 32.00, 28.00, respectively, and the mean difference of two groups is 4, which is not statistically significant difference ($t= .465$, $p> .05$).

Table 2. Comparison of means of achievement in the pretest of two groups

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Control	15	32.00	24.33	28	.465*
Experimental	15	28.00	22.77		

($p > .05$)

Post-test Results

Table 3 shows the means of achievement in pretest and posttest of experimental group, of which are 28.00, 48.33, respectively. The mean difference in two tests is 20.3, which is statistically significant (t = -4.532, p< .05).

Table 3. Comparison of means of achievement of the experimental group

Pretest	15	28.0	22.7	4.532*
Posttest	15	48.3	16.9	

(* : p <.05)

And, table 4 shows the means of achievement in pretest and posttest of control group, of which are 32.00, 50.33, respectively. The mean difference in two tests for control group is 18.3, which is statistically significant, too (t = -4.785, p< .05).

Table 4. Comparison of means of achievement of the control group

Pretest	15	32.0	24.3	4.785*
Posttest	15	50.3	25.7	

(* : p <.05)

The both results above imply that traditional instruction as well as instruction with Model-Modifying activities affected for the students' learning achievement positively. Therefore, to find which method is more effective for students' science learning, the post-test results of two groups should be compared. Table 5 shows the means of achievement in post-test of both groups. The means of achievement of control and experimental groups are 50.3 and 48.3, respectively, and the mean difference of the two groups is 2.0, which is not statistically significant difference ($t=.378$, $p>.05$). This result denies our expectation that the instruction with model-modifying activities is better than the traditional instruction for the students' learning of physics concepts. Therefore, we did in-depth analysis about the results. In this analysis we found that correlation between the students' validation level of modified models and posttest result of the experimental group.

Table 5. Comparison of means of achievement in the posttest of two groups

Group	n	Mean	Std. Deviation	t
Control	15	50.3	26.7	.378*
Experimental	15	48.3	16.9	

(*: $p > .05$)

Model Modifying Activity Results

As the table 6 shows, Pearson correlation coefficient, r, between the two factors is .522 and the statistics shows that the correlation is statistically significant ($p < .05$). Noticing the high correlation, we compared the increments of students' achievement with the level of validation, and it makes us to infer that the validation level is to some extent related to the increase of students achievement. Eight out of fifteen students showed high scores in the validation level (20points ~38 points) and showed also high increments in achievements (20points~40points).

Table 6. Correlation between validation levels of modified models and achievement in posttest of the experimental group

	Achievement in Posttest
Validation level of modified models	.52*
n	15

(* : p <.05)

We reviewed students' own modified models again in view of conceptual change and found that some students represent alternative concepts in their modified model. Fig. 1 shows an example of students alternative ideas, this student is aware that the velocity can be computed as the length of a line in his/her modified model.

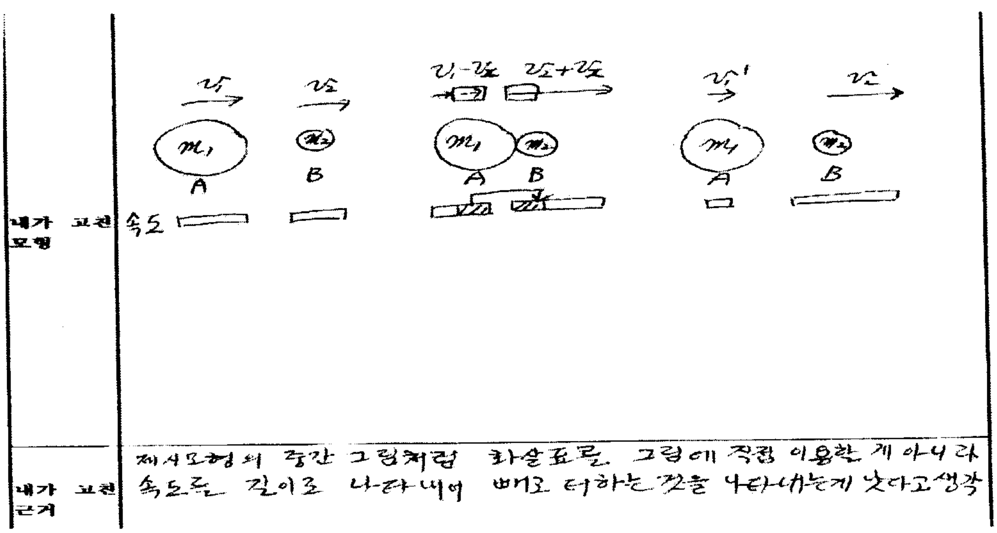

Fig 1. One example of a scientific model modified by a gifted student

IV. CONCLUSIONS AND IMPLICATIONS

RESEARCH

According to this research results, we can't insist the instruction with Modifying Activities of Scientific Models is better than the traditional instruction. But the increment after instruction of experimental group is more than that of control group, and there is some correlation between validation levels of modified models and achievements in posttest. And through analyzing of the models modified by students, we found that they concentrated on the scientific conceptual models without glancing and they had some misconceptions in science. These give us a clue about possibility of effectiveness of that teaching strategy, model modifying activity, and those are why we introduce the learning strategy of model modifying activity and effectiveness of the teaching results using it in spite of no obvious evidence.

Actually we have some evidence in using of model completion activity for science teaching (Kim, et. al., 2004), but that method is not for the gifted but for the ordinary students. And model modifying activity is a little difficult for the 8th graders even though they are high achievers in science. We feel that we need more and various researches in this theme, and now we are investigating about the effectiveness when the model completion activity is applied to the gifted. Moreover, in this research, just only two periods of instruction were administered to the experimental group, it may not be enough for improving their achievement more than traditional method, so we need to investigate the results after many periods of instruction with Model-Modifying activities. And there are a few methods of model modifying activities, the method used in this research is just one of them. Another strategies of model modifying activities are expected to develop and implement in science classes for the gifted.

Lastly, we found that the model modifying task could be used for checking of students' alternative ideas. In this research, investigating of students' misconceptions was not a purpose, but it was found that students' misconceptions could be analyzed through reviewing their works.

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