Naive Theories about Gravity among Korean Students

Dong-Hyun Chae
(Kongju National University Instructor)

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Ⅰ. INTRODUCTION

Students tend to develop about natural phenomena based on their direct experience, observations, and cultural backgrounds. These theories can often cause difficulties when students apply what they have learned to predict and describe natural phenomena. Champagne and Klopfer(1983) suggest that the failure of these students is related to the persistence of naive theories brought with them to science classes.

These naive theories seem to persist even when students are exposed to traditional instructional methods(Champagne & Klopfer, 1983). Bodner (1986) suggested that knowledge previously acquired through everyday experience has serious implications for science learning because this knowledge is deeply rooted in the learner's direct experience.

This study explores the existence and persistence of naive theories about gravity, and investigates teaching strategies to overcome these naive theories.

The research questions of this study are as follows: 1) What are Korean 6th-, 8th-, and 10th-grade students' naive theories about gravity (Ⅰ) and (Ⅱ)? 2) How are Korean 6th-, 8th, and 10th-grade students' conceptions about gravity (Ⅰ) and (Ⅱ) distributed across the Scientific, Naive, and "No" Model categories? 3) How do student responses to the open-ended written question format compare to the responses to an interview format for identifying students' naive theories? 4) What are teaching strategies to overcome these naive theories?

Ⅱ. LITERATURE REVIEW

1. Nature of the Learner

A conference of 45 leaders in science education, which was convened in January, 1986, at the Uni-

versity of California, Berkeley with support from the National Science Foundation, forged new understanding of the directions in which science education research is moving. One theme emerging from this research is the need to understand the nature of the learner(Linn, 1987).

Consideration of the learner has been heavily influenced by Ausubel. According to Ausubel (1968), "If I had to reduce all of educational psychology to just one principle I would say this: the most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly(p. iv)". This means that the learner may come to a learning situation with an understanding of the world phenomena to be studied which is often different from the scientific explanation. Thus, it is important to identify precisely what the learner already knows.

2. Constructivist Perspective of Learning Theory

There have been two points of view with respect to learning theories in science education since the early part of the twentieth century. They come from the behaviorists and the cognitive psychologists.

Behaviorists, who were most influential during the first half of the twentieth century, consider the learner as a black box and focus their research efforts on relationships between stimulus, response, reward, and reinforcement. Researchers working from the behaviorist perspective often investigate methods for fostering student understanding without considering the individual characteristics of subjects.

Cognitive psychologists, on the other hand, place more importance on cognitive processes and the characteristics of the learner. Constructivism, which has become influential, asserts that knowledge is constructed in the mind of the learner on the basis of pre-existing cognitive structures or schemes. Bodner(1986) asserts that constructivism originates from Piaget's work, stating that Piaget believed that knowledge is constructed as the result of a life-long constructive process in light of existing schemes of thought. Constructivism is based upon the Piagetian model including the constructs of assimilation, accommodation, and equilibration. Assimilation involves applying a preexisting scheme to deal with new phenomena. Accommodation involves modifying an existing scheme to fit new situations. Equilibration is the process of restoring balance between present understanding and new experiences.

A constructivist view of learning is analogous to helping a student find the right "fit"for himself or herself between knowledge and reality. Constructivists' views conflict with traditional behaviorists' views, who seek to "match" knowledge with students (Bodner, 1986). According to constructivists, students' naive concepts and prior learning strongly influence the construction of knowledge so as to "fit" what they perceive of the world, in the same way that many keys may be available to open the same lock.

The present study is based on a constructivist view of learning theory to amass evidence related to student conceptions.

3. Open-Ended Written Questions and Interviews for Identifying Naive Theories.

There has been much research on students' conceptions in science education since 1950. One issue which has emerged from this research concerns methodologies for identifying students' conceptions. Three types of research methods have traditionally been used to identify students' conceptions: 1) interviews(Cosgrove & Osborne, 1983; Nussbaum & Novak, 1976) 2) multiple choice tests(Wandersee, 1985) and 3) open-ended written questions(Bar, 1987; Bar & Travis, 1991).

Interviews have been used in many recent investigations of students' science conceptions.

Gunstone, White, and Fensham(1988) point out that if we want to know how learners conceptualize the real world of natural phenomena and to investigate how or why individual learners differ in their ideas about the real world of natural phenomena and to investigate how or why individual learners differ in their ideas about the real world of natural phenomena, we need to use interviews. On the other hand, interviews and very time-consuming and require substantial training, and so it is not easy for teachers to identify every individuals' naive theories within large classroom settings (Treagust, 1987).

Multiple choice tests are easy to score at the beginning or upon completion of a specified science topic, so that any science teacher may easily obtain a measure of students' conceptions. One difficulty is to construct an instrument which will detect the many different conceptions that students have about the natural world. Ridgeway (1988) indicates that students' conceptions vary from student to student and from year to year. Furthermore, multiple choice tests may be less valid because they may be read and interpreted in unintended ways.

Open-ended written questions can be applied to large classroom settings and elicit the variety of unique responses held by students. Bar(1987) suggests the use of open-ended written questions because of this capability. Bar(1987) conducted research comparing the effectiveness of interviews, multiple choice tests, and open-ended written questions for eliciting students' concepts. Bar (1987) found that open-ended written questions elicit responses similar to those of the interviews, while multiple choice tests show significantly different results. Bar and Travis(1991) investigated the effects of the formats of the testing on student responses. Bar and Travis(1991) confirmed that the open-ended written questions elicit responses similar to those of the interviews, but multiple choice tests elicit the different responses.

This study will compare an open-ended written question format with an interview format.

Ⅲ. METHODOLOGY

1. Sample

The sample for this study consists of 151 Korean students: 49 sixth grade students in one class from one elementary school, 53 eighth grade students in one class from one junior high school, and 49 tenth grade students in one class from one senior high school. These classes were randomly selected from each grade. These schools are located in Kongju City, in the northwestern part of South Korea. The elementary school from which students were selected is composed of students of both sexes. The junior high school and senior high school are composed of students of one sex(male).

2. Instrument

One instrument, called Identification of Naive Theories Test in Earth Science(INTTES) was developed for this study (See APPENDIXA). The instrument were patterned after instrument used by Nussbaum and Novak(1976) with some modification. The INTTES includes gravity (2 items).

A Korean version of INTTES was distributed to three intact classes for the assessment: 49 elementary school students in sixth grade, 53 junior high school students in eighth grade, 49 senior high school students in tenth grade.

3. Data Gathering Procedures

The methods were to administer the INTTES first, followed by the interviews. The researcher visited each of the schools chosen and administered the INTTES between July 30, 1991 and August 5, 1991. Participants were asked to explain their answers with words and drawings and to indicate their sources of knowledge. Participants were allowed to ask questions during the

INTTES examination process so that the researcher could confirm that the participants understood the directions and the items. Participants were allowed as much time as needed. All students finished within 10 minutes.

After a lapse of one week, interviews began. The interview participants were taken to Kongju National University located at Kongju City. To help establish communication and bulid trust with the researcher, participants were taken to the planetarium. In the planetarium, participants were told about astronomy and different kinds of telescopes.

The researcher interviewed the students individually. While not being interviewed, the students were given the opportunity to watch telvision in another room.

The items(question) were analyzed in terms of research questions. For this item (question), key phrases within students' answers were indentified on the INTTES across item(question). For the 15 students who responded to both the INTTES and to the interviews, if students' answers on the INTTES were not consistent with those in the interview, students' interview answers were used in the data analysis. Since the interview was based upon a review of the students' responses on the INTTES, the researcher felt that the students' interview answers provided more information. The key phrases were grouped into the different categories: Scientific Model, Naive Model, or "No" Model.

To validate the open-ended written questions (INTTES), key phrases within students' answers were indentified through the INTTES and interview settings and then compared. The subjects used for comparing the students responses to the INTTES and to the interview settings were 15 students who had responses to both the INTTES and the interview settings.

Ⅳ. RESULTS

1. What are Korean 6th, 8th, and 10th Grade Students' Naive Theories(Models) about Gravity(Ⅰ) and (Ⅱ)?

First, percentages of 6th, 8th, and 10th grade student responses to the question about gravity (Ⅰ) are shown in Table 1. Student responses were categorized into 8 response groups. The student responses were presented in order from the most frequent response group down to the least frequent group except for the "No" Model. When frequencies of a response group are equal, the group with more upper Grade Level student responses is given first.

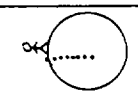
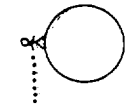
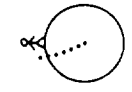
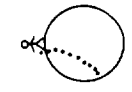
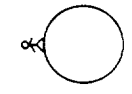
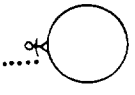
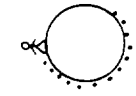
Response group 1(*) represents those responses which are correct result combined with correct reasons and includes 76% of 6th grade, 91% of 8th grade, and 86% of 10th grade students, who believed that the rock would fall toward the center of the Earth. With regard to reasons given for their answers, they explained that gravity would pull the rock down toward the center of the Earch (Scientific Model).

Response group 1(**) represents those responses which are correct results combined with incorrect reasons and includes 8% of 6th grade and 2% of 10th grade, who believed that the rock would fall toward the center of the Earth. With regard to reasons given for thier answers, 6% of 6th grade students stated that pressure would pull the rock down toward the center of the Earth, 2% of 6th graded students indicated that the rock would fall down toward the center of the Earth because there is no air, and 2% of 10th grade students explained that gravity and the Earth's rotation pull the rock down toward the center of the Earth(Naive Model).

Response group 2, containing 8% of 6th grade and 6% of 8th grade students, believed that the rock would fall downward in relation to the orien-

tation of a page of print(see response group 2 in Table 1). Of these students, 6% of 6th grade and 6% of 8th grade students explained that it was natural that if we drop something in space, it would fall downward in relation to the orientation of a page of print(Naive Model). Two percent of 6th grade students reasoned that the Earth's rotation would cause the rock to fall downward in relation to the orientation of a page of print(Naive Model).

Table 1. Porcentages of Student Responses to the Question about Gravity (1) by Grade

Response Group		Grade 6	8	10	Remarks
1.		76 8	91 0	86 2	*(correct result /correct reason) * * (correct result/incorrect reason)
2.		8	6		**
3.				6	**
4.				4	**
5.		4			**
6.		2			**
7.		2			**
8. I don't know			4	2	***

* Scientific Model ** Naive Model
*** "No" Model

Response group 3, which includes 6% of 10th grade students, believed that the rock would fall at an angle toward the surface of the Earth(see response group 3 in Table 1). They reasoned that the rock would fall at an angle toward the surface of the Earth because of the Earth's rotation(Naive Model).

Response group 4, which includes 4% of 10th grade students believed that the rock would fall in a curved path as shown in response group 4 in Table 1. Two percent of 10th grade students reasoned that there is a Coriolis effect owing to the Earth's rotation (Naive Model). Two percent of 10th grade students reasoned that there is no air to pull the rock down in any direction(Naive Model).

Response group 5, consisting of 4% of 6th grade students, believed that the rock would remain in the original position(see response group 5 in Table 1). Of these students, 2% of the students reasoned that there is no gravity to pull the rock down(Naive Model) and 2% of the students reasoned that there is no air to pull the rock down (Naive Model).

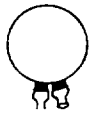
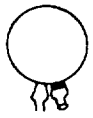
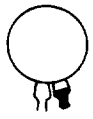
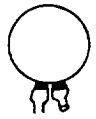
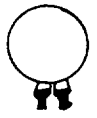
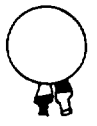
Response group 6, consisting of 2% of 6th grade students, believed that the rock would fall away from the surface of the Earth (see response group 6 in Table 1). The reason given was that there is no air around the Earth (Naive Model).

Response group 7, which includes 2% of 6th grade students, believed that the rock would fall down and move in a circular path around the Earth(see response group 7 in Table 1). The reason given was that the rock would fall down and that the Earth is circular in shape(Naive Model).

Response group 8, which includes 4% of 8th grade and 2% of 10th grade students, did not provide any responses to this question("No" Model).

Second, percentages of 6th, 8th, and 10th grade student responses to the question about the gravity (Ⅱ) are shown in Table 2.

Table 2. Percentages of Student Responses to the Question about Gravity (Ⅱ) by Grade

Response Group	Grade 6	8	10	Remarks
1. 	55 17	81 4	90 4	*(correct result /correct reason) * * (correct result/incorrect reason)
2. 	10	2		**
3. 	12			**
4. 			2	**
5. 		2		**
6. 	2			**
7. I don't know	4	11	4	***

* Scientific Model ** Naive Model
*** "No" Model

Student responses were categorized into 7 response groups. The student responses were presented in order from the most frequent response group down to the least frequent group except for the "No" Model. When frequencies of a response group are equal, the group with more upper Grade Level student responses is given first.

Response group 1(*) represents those responses which are correct results combined with correct reasons and includes 55% of 6th grade, 81% of 8th grade, and 90% of 10th grade students, who believed that the bottom of the bottles would be toward the center of the Earth and the water in the bottles would remain at the bottom of the bottles. With regard to reasons given for their answers, they explained that gravity would cause the bottom of bottle to be toward the center of the Earth and the water in the bottles to be at the bottom of the bottles(Scientific Model).

Response group 1(**) represents those responses which are correct results combined with incorrect reasons and includes 17% of 6th grade, 4% of 8th grade, and 4% of 10th grade students, who believed that the bottom of bottle would be toward the center of the Earth and the water would remain in the original state. With regard to reasons given for their answers, 14% of 6th grade and 4% of 8th grade in this response group claimed that the water in the bottles would be frozen at the South Pole and that the bottom of the bottles would be toward the center of the Earth. These students did not have an explanation as to the Earth(Naive Model). Also, 4% of 10th grade students in this response group claimed that the water in the bottles would be frozen at the South Pole because the South Pole is colder than the North Pole and that the bottom of the bottles would be toward the center of the Earth. These students did not explain why the bottom of the bottles would be toward the center of the Earth (Naive Model). Two percent of 6th grade stu-

dents reasoned that a lack of air would cause the water to stay at the bottom of the bottles; these students also did not explain why the bottom of the bottles would be toward the center of the Earth(Naive Model).

Response group 2 includes 10% of 6th grade and 2% of 8th grade students who believed that the bottom of the bottles would be toward the center of the Earth, that the water in the closed bottle would remain at the bottom of the bottle, and that the water in the open bottle would be gone(spill out) (see response group 2 in Tabel 2). The explanations given were as follows: 1) 6% of 6th grade students indicated that the bottom of the bottles would be toward the center of the Earth and there is no cap for one of the bottles, and so there would be no water in the open bottle (Naive Model); 2) 2% of 6th grade students indicated that the South Pole was warmer than the North Pole, and so there would be no water in the open bottle (Naive Model). Perhaps this is related to a change in phase from solid to liquid, therefore allowing the water to spill out; 3) 2% of 6th grade students indicated that the water in the bottles depended on the cap, and so the water in the closed bottle would remain in the original state and the water in the open bottle would empty from the bottle(Naive Model); 4) 2% of 8th grade students reasoned that the water in the closed bottle was covered by a cap and so would be frozen, but the water in the open bottle was not covered by a cap, and so the water would empty from the bottle(Naive Model). The students in this response group did not mention that gravity would cause the bottles to be toward the center of the Earth.

Response group 3 includes 12% of 6th grade students who believed that the bottom of the bottles would be toward the center of the Earth, that the water in the closed bottle would be at the top, and that there would be no water in the open bottle(see response group 3 in Table 2). The students reasoned that there is air around the Earth; therefore, the water in the closed bottle would be at the top and there would be no water in the open bottle(Naive Model). The students in this response group did not mention gravity as the reason that the bottom of the bottles would be toward the center of the Earth.

Response group 4 includes 2% of 10th grade students who believed that the bottom of the bottles would be toward the center of the Earth, that the water in the closed bottel would remain in the original state, and that the volume of water in the open bottle would be less(see response group 4 in Table 2). The reason given was that when the girl took the bottles to the South Pole, the girl would pass the equator(Naive Model). The student did not mention why the bottom of the bottles would be toward the center of the Earth.

Response group 5, which also includes 2% of 8th grade students, stated that the bottom of the bottles would be toward the center of the Earth and that the water in both bottles would be at the top(see the response group 5 in Table 2, Naive Model). The students did not give a reason for the answer.

Response group 6, which includes 2% of 6th grade students, believed that the bottom of the bottles would be toward the center of the Earth, that the water in the closed bottle would remain in the original state, and that the water in the open bottle would be at the top(see response group 6 in Table 2). The reason given was that there is no air around the Earth. Therefore, the lack of air would cause the water in the closed bottle to remain in the original state and the water in the open bottle would be at the top(Naive Model). The student did not explain why the bottom of the bottles would be toward the center of the Earth.

Response group 7 includes 4% of 6th grade, 11 % of 8th grade and 4% of 10th grade students

who did not provide any responses to this question ("No" Model).

2. How are Korean 6th, 8th, and 10th Grade Students' Conceptions about Gravity (Ⅰ) and (Ⅱ) Distributed across the Scientific, Naive, and "No" Model Categories?

First, Table 3 show that the majority of all students at all three Grade Levels held the Scientific Model(76~91%) with the 8th grade students (91%) having a significantly greater($p<0.05$) tendency toward Scientific Model than the 6th grade students(76%). A Naive Model was reflected by a small number of students(6~24%) with the 6th grade students(24%) having a significantly greater ($p<0.01$) tendency toward Naive Model than the 8th grade students (6%). The incidence of these Models did not show a linear trend related to Grade Level. For this question, the chi-square analysis did not show a statistically significant overall pattern($x^2=9.17$, $p=.057$).

Table 3. Contingency Tables Comparing Models with Each Grade Level for Gravity(Ⅰ)

	"No" Model	Naive Model	Scientific Model
6th grade (n=49)	0%	24%	76%
8th grade (n=53)	3%	6%	91%
10th grade (n=49)	2%	12%	86%

$x^2=9.17$, $p=.057$

Second, Table 4 shows that the majority of all students at all three Grade Levels held the Scientific Model(55~90%) with the 10th grade students(90%) and the 8th grade students(81%) having a significantly greater($p<0.01$) tendency toward Scientific Model than the 6th grade students(55%). A Naive Model was reflected by a smaller number of students (6~41%) with the 6th grade students (41%) having a significantly greater($p<0.01$) tendency toward Naive Model than the other grades(6~8%). There appears to be a a progressive increase in the percentage of students holding Scientific Model from the 6th grade students(55%) to the 8th grade students (81%) to the 10th grade students (90%) and a corresponding decrease in the percentage of the students holding Naive Model from the 6th grade students(41%) to the 8th grade studens(8%) to the 10th grade studens (6%). For this question, the chi-square analysis did show a statistically significant overall pattern($x^2=28.34$, $p=.00001$).

Table 4. Contingency Tables Comparing Models with Each Grade Level for Gravity(Ⅱ)

	"No" Model	Naive Model	Scientific Model
6th grade (n=49)	4%	41%	55%
8th grade (n=53)	11%	8%	81%
10th grade (n=49)	4%	6%	90%

$x^2=28.34$, $p=.00001$

3. How do Student Responses to the Open-Ended Written Question Format Compare to the Responses to an Interview Format for Identifying Students' Naive Theories?

One of purposes of the interviews in this study was to investigate students' naive theories which might be overlookedby the Identification of Naive Theories Test in Earth Science (INTTES) and to validate the INTTES.

The subjects used for comparing the student responses to the INTTES and to the interview were 15 students who had responses to both the

INTTES and the interview. Key phrases within student responses to the INTTES and the interview were identified and compared. A comparison of INTTES and the interview is shown in appendix B. appendix B shows 93% agreement between the INTTES and the interview.

4. What are Teaching Strategies to overcome These Naive Theories?

Osborne (1980) suggests that teachers use activities which provide students with challenges and encouragement to rethink their ideas, to elaborate these ideas, and to change their ideas.

On the gravity (I) question, 2% of 6th grade students indicated that there is no air to pull a rock down. A suitable activity which might move students toward a Scientific Model is the "coin and feather" experiment. A glass tube is evacuated using a vacuum pump and then a feather and a coin are dropped simultaneously. It is seen that "coin and feather" fall at the same rate and reach the bottom at the same time. This experiment demonstrates that objects fall at the same time rate and that gravity acts on objects whenever there is no air around them. Six percent of 10th grade students indicated that the Earth's rotation would affect gravity, by believing that the rock would fall at an angle toward the surface of the Earth(see response group 3 in Table 1). One possible experiment would be to place a student seated in a stationary bus and have the student drop a coin into a cup placed on the floor of the bus. The student would then be asked to drop the coin into the cup while the bus was moving at a constant velocity. The student would be able to note that the coin trajectory was the same in both instances, straight up and down. This experiment would help to illustrate that there are no relationships between the Earth's rotation and gravity.

On the gravity (II) question, 2% of 6th grade students indicated that the water in the bottles depended on the cap, and so the water in the closed bottle would remain in the original state and the water in the open bottle would empty from the bottle. One possible experiment would use a bottle and a metal globe. The bottle would have a magnet attached to the bottom which would be attracted to the globe. The student would fill the bottle half full of water and place it onto the globe with the North Pole pointing up. The student would then be instructed to hold the bottle stationary while moving the globe go that the South Pole is facing in an upward direction.

The student would be able to see that the water does not fall out of the bottle when moving from the North Pole to the South Pole. Therefore the student will see that a bottle without a cap will have the same amount of water as a bottle with a cap when walking from the North Pole to the South Pole.

Another suggestion to textbook and curriculum developers is to include common student naive theories and experiment, demonstrations, or readings which would help in changing them. These should be available in the teacher guides and teacher editions of textbooks for this topic.

V. CONCLUSIONS

Naive theories were found to persist across Grade Levels including high school level students. These naive theories involved confusion related to the shape and movement of the Earth, influence of air/no air/air pressure, influence of cap, influence of phases of matter, and influence of temperature. A higher percentage of the students held scientific theories, and there was a consistent increase in the percentage of students using scientific theories as Grade Level increases. The results from the interviews and the INTTES instrument were extremely consistent.

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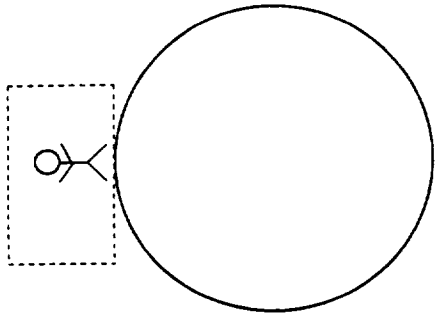
APPENDIX 1

Identification of Naive Theories Test in Earth Science

(INTTES)

Grade Level .....
Class .....
Name .....

1. In the following picture, a little girl stands on the Earth. This little girl has a rock in her hand and she is going to drop the rock. In which direction would the rock fall?



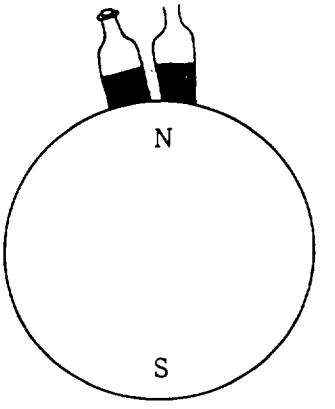
1) Draw a line showing the direction in

which the rock would fall:

2) Explain your answer. .....
.....
.....

3) Where did you first learn about this? .....
.....

2. This picture shows two bottles on the North poie. One of them is closed and the other is opened. Both are half−filled with water. Suppose that a little girl takes the bottles to the South pole. What happens to the positions of the bottles and to water in the bottles?



1) Draw a picture of the bottles at the South pole and tell what would happen to position of the bottles and to the water in the bottles:

2) Explain your answer. .....
.....
.....

3) Where did you first learn about this? .....
.....

APPENDIX B

A Comparison of the Open−Ended Written Questions(INTTES) and the Interview of Identifying Naive Theories

Student	Grade	Item	INTTES	Interview	Remarks
1	6	1	Toward center of Earth; gravity	Toward center of Earth; gravity	
		2	Toward center of Earth; remain in origial state; gravity	Toward center of Earth; remain in original state; gravity	
2	6	1	Toward center of Earth; gravity	Toward center of earth; gravity	
		2	Toward center of Earth; remain in original state; gravity	Toward center of Earth; remain in original state; gravity	
3	6	1	Toward center of Earth; gravity	Toward center of Earth; gravity	
		2	Toward center of Earth; remain in original state; gravity	Toward center of Earth; remain in original state; gravity	
4	6	1	Toward center of Earth; gravity	Doeneard	
		2	Toward center of Earth; remain in orginal state; gravity	Toward center of Earth; remain in original state; gravity	
5	6	1	Toward center of Earth; gravity	Toward center of Earth;remain	
		2	Toward center of Earth; remain in original state; gravity	in original state; gravity	

Student	Grade	Item	INTTES	Interview	Remarks
6	8	1	Toward center of Earth; gravity	Toward center of Earth; gravity	
		2	Toward center of Earth; frozen	Toward center of Earth; frozen	
7	8	1	Toward center of Earth; gravity	Toward center of Earth; gravity	
		2	Toward center of Earth; remain in orginal state; gravity	Toward center of Earth; remain in original state; gravity	
8	8	1	Toward center of Earth; gravity	Toward center of Earth; frozen; gravity	
		2	Toward center of Earth; remain in original state; gravity		
9	8	1	Toward center of Earth; gravity	Toward center of Earth; gravity	
		2	Towardcenter of Earth; remain in original state;	Toward center of Earth; remain in original state;	
10	8	1	Toward center of Earth; gravity	Toward center of earth; gravity	
		2	Toward center of Earth; remain in original state; gravity	Toward center of Earth; remain in original state; gravoty	
11	10	1	Toward center of Earth; gravity	Toward center of Earth; gravity	
		2	Toward center of earth; state; gravity	Toward center of Earth; remain in original state; gravity	
12	10	1	Toward center of Earth; gravity	Toward center of Earth; remain in original state; gravity	
		2	Toward center of Earth; remain in original state;gravity		
13	10	1	At angle toward surface of Earth; gravity & Earth's rotantion	At angle toward surface of Earth; gravity & Earth's rotantion	
		2	Toward center of Earthl frozen	Toward center of Earthl frozen	
14	10	1	Toward center of Earth; gravity	Toward center of Earth; gravity	
		2	toward center of Earth; remain in original state; gravity	Toward center of Warth; remain in original state; gravity	
15	10	1	Toward center of Earth; gravity	Toward center of Earth; gravity	
		2	Toward center of Earth; remain in original state gravity	Toward center of Earth; remain in original state; gravity	

* a difference between the student recponses to the INTTES and to the interview

국문초록

한국 학생들의 중력현상에 관한 유년적 사고

채 동 현
(공주대 강사)

학생들은 수업전 그들의 일상적인 경험, 직접적인 관찰, 문화적인 배경으로 인하여 자연 현상에 관하여 과학자가 지니는 과학적 사고(Scientific theories)와는 다른 유년적 사고(Naive theories)을 지니고 있다는 사실이 연구에 의하여 보고되어 왔다.

본 연구는 중력현상에 관한 학생들의 유년적 사고(Naive theories)를 조사한 것이다. 이의 대상은 국민학생 49명, 중학생 53명, 고등학교 49명으로 하였다. 연구 방법으로는 질문지법(Open-ended written questions)과 면접법(Interview)을 이용하였다.

연구 결과는 국민학생에서 고등학생에 이르기까지 중력현상에 관하여 유년적 사고(Naive theories)를 지니고 있는 것으로 밝혀졌다. 중력현상에 관한 유년적 사고(Naive theories)들은 중력현상이 공기의 유무, 대기압, 마개의 유무, 물의 상태변화, 온도의 영향등으로 지배를 받는다고 설명하였으며, 이러한 생각은 고학년으로 갈수록 줄어들고 있음을 볼 수 있다.
질문지법(Open-ended written question)과 면접법(Interview)의 결과가 매우 일치하는 것으로 밝혀졌다.