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Study of Conceptual Development using "The Four-Wheel Cart and The Little Hill" Unit From The Taiwanese Elementary School Natural Science Reader

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INTRODUCTION

This study is intended to investigate whether the "The Four-Wheel Cart and The Small Hill" unit of the textbook currently used to teach natural sciences to upper-division elementary school students successfully helps students to develop effective methods for conceptualizing and resolving natural science problems. According to the experience of many teachers, many students have naive concepts, preconceptions, misconceptions and alternative framing methods which do not match the concepts or the conceptualization methodologies of experts. This study is intended to determine whether "The Four-Wheel Cart and The Small Hill" unit of the current upper-division elementary school textbook helps students to effectively overcome these problems. The data and the results of this research are intended to assist those educators who are planning to revise the current selection of natural science textbooks.

The researcher has attempted in this paper to identify and catalog a number of misconception models which plague elementary school students and to assist in remedying these student misconceptions. Among the items which this researcher has attempted to catalog are preconceptions, naive conceptions, alternative frames and misconceptions.

The study used a total of fourteen students. These students represent a sampling of students selected from 14 different elementary schools located in both Taipei city and Taipei county. Nine of the elementary schools were located in urban districts. The other five elementary schools were located in suburban districts.

The schools represented in the sampling are as follows:

In Taipei City:

The Mandarin Laboratory Elementary School, The Ta-An Elementary School
The Ta-Long Elementary School, The Wen-Lin Elementary School
The Nan-Kong Elementary School, The Nei-Fu Elementary School
The Fu-An Elementary School, The Chan-Chun Elementary School
The So-Tsu Elementary School, The Fu-Lu Elementary School

In Taipei County:

The Pin-Ding Elementary School, The Wang-Si Elementary School
The Ying-Ho Elementary School, The Wen-Sen Elementary School

All sampled subjects were sixth graders between the ages of eleven and twelve years old.

The experiment with each student was broken up in to three discrete parts. First, an interview was conducted with each student before the lesson was taught. The interview was comprised of a list of questions included later in this paper. The second part of the experiment involved the student studying the unit with their usual teacher in their accustomed classroom environment. The third and final part of the study involved a second interview with each student. In this interview the students were again asked the full battery of questions posed to them in the first interview.

All interviews were both tape-recorded and video-taped by the researcher in a standard interview setting.

The first battery of interviews were conducted between September 28 1992 and December 15 1992. The second battery of interviews were conducted between December 1 1992 and December 31 1992. All interviews were conducted at the Taipei Municipal Teachers' College.

LITERATURE REVIEW

Elementary school natural science textbooks are periodically revised in order to meet new social needs. The current series of natural science textbooks were developed in 1978 and have been revised two times since. These textbooks were developed using materials gathered from the ESS, the ISCS and a number of textbooks on traditional natural science teachings developed in China. Many experts in the field of science education in Taiwan believe that future textbooks will require modifications which will both keep students up to date with current trends in science and help those students to frame their understanding of science in a fashion which allows them to apply their knowledge in the real world.

The researcher of this paper has chosen the unit "The Four Wheel Cart and The Small Hill" from the current upper-division elementary school natural science textbook. This has been done in order to identify and catalog a number of the naive conceptions, preconceptions, alternative frames, and misconceptions which elementary school students currently encounter in their attempts to understand the physical phenomena explained within this unit. It is the intention of this researcher to make this information available as a reference to the developers of future natural science textbooks.

There are a number of other studies which have been on this subject. Excellent examples of this type of research were carried out by Huang and Huang (Huang Xiang-Wu and Huang Bao-Dian,1989: research involving the conceptual development of junior high school students studying science), Wang Long-Xi (1991: nationwide research involving the elementary school student conceptions concerning straight light experiments), and Brown, Clement, Champagne and Tennyson (Brown, Clement, et.al., 1992: research using examples and analogies to help remedy student misconceptions).

According to Sjoberg and Lie (Sjoberg and Lie, 1981) naive conceptions will retard children's conceptual learning speeds. Brown (Brown, 1992) further points out that misconceptions can prevent the construction of science conceptions. It is therefore the purpose of this paper to identify and catalog a number of naive conceptions, preconceptions, alternative frameworks and misconceptions which threaten to impede the learning processes of students. The researcher of this paper has chosen "The Four Wheel Cart and The Small Hill" unit of the current

upper-division elementary school natural science textbook in order to do this. Having done this the researcher hopes to provide information useful for developing new scientific conceptualization methodologies for the Republic of China on Taiwan.

The researcher has defined the items he is examining in the following fashion:

Scientific: Using reasoning methods used by scientists to arrive at accurate explanations for natural phenomena.

Naive Conceptions: Non-Scientific concepts or conceptual models developed by students before receiving schooling.

Preconceptions: Concepts or conceptual models held by students and based on day-to-day experiences, which have been developed by students before receiving schooling.

Alternative Frameworks: Methodologies or models used by students to frame explanations for scientific phenomena which are unique to the individual student's thinking patterns.

Misconceptions: Methodologies or models used by students to frame explanations for scientific phenomena which do not succeed in correctly explaining the causes for these phenomenon.

Conceptualization Methodology: Any method used to conceptualize and analyze the causes of a natural phenomenon.

INTERVIEW QUESTIONS

(I). Angle and Slope

(1) Do you have any experience riding bicycles?

(a) If you rode a bicycle would it be more tiring to ride up a steep hill or along flat ground? Why?

(b) Which would be faster: Riding down a steep hill or riding down a steep hill or riding down a hill which was not as steep? Why?

(2) Do you have any experience playing on slides?

(a) Which kind of slide do you like the best? A very steep slide or a slide which is not so steep?

(b) Which of these two types of slides do you think you would slide down faster?

Why?

(c) If you set a paper box at the foot of each of these types of slides and then slid down, which box do you think you would kick farther: The box at the foot of the very steep slid or the box at the foot of the not so steep slide? Why?

(II) Length and Distance

(1) Two bicycles travel down the slide of a mountain slope at the same angle. One of the bicycles starts from the top of the mountain, the other bicycle starts from half-way up the side of the mountain. Which bicycle do you think will be traveling faster when it reaches the foot of the mountain? Why?

(2) Two bicycle travel down the side of a mountain slope at the sample angle. One of the bicycles starts from the top of the mountain. The other bicycle starts from half-way up the side of the mountain. which bicycle do you think will roll farther once it reaches the foot of the mountain? Why?

(3) Two bicycles travel down the side of a mountain slope at the same angle. One of the bicycles starts from a height of five meters. The other bicycle starts from a height of three meters. If each of these bicycles struck a paper box placed at the foot of the mountain which one would strike the box further? Why?

(III). Weight and Mass

(1) Do you have any experience playing on water slides?

(2) You and your father slide down a water slide and fall into a pool of water. Which of you will displace more water? (make more water come out?)

(IV). Mass and Resistance

(1) There are two students. One of the students is fat. The other student is thin.

Which of these two students will find it easier to stop a rolling cart: The fat student or the thin student? Why?

(2) A sixth grade student and a first grade student are both bumped into by third grade students running down a staircase. What will happen? Who will get knocked over and who will not get knocked over? Why?

RESULTS AND ANALYSES

Case 1: analysis of sample student 1

The first sample student in response to the first question said that it would be more tiring to go up the steep hill, but could not give a reason for this response, when the second interview was conducted sample student 1 was able to explain that the bicycle trip up the steep hill would be more tiring due to the steep angle of the ascent.

These responses seem to indicate a preconception on the part of sample student 1 which is later proven true by the use of a scientific conception method.

In response to question 2 sample student 1 indicated the belief in interview 1 that a bicycle traveling down the less-steep of the two hills would travel more quickly than a bicycle traveling down the steeper slope. Again, sample student 1 was unable to give a reason for this belief. However, after taking the lesson sample student 1 had decided that the previous interviews' answers were incorrect. Sample student 1 was then able to indicate that the bicycle moving down the steeper incline would move more quickly and was able to pinpoint that the cause was the reduced resistance of the steeper hill.

These responses seem to indicate a misconception on the part of sample student 1 which is later proven false by the use of a scientific conception method.

Sample student 1's responded to question 3 in the first interview was very similar to that of his response to question 1. Sample student 1 correctly answered that a box kicked by a student going down the steeper of two slides would fly further, but again was unable to explain why this was so.

In the second interview sample student 1 was able to produce not only a correct answer to the problem but also a concise reason for the answer.

In sample student 1's first interview question 4 was also answered correctly. The student recognized that the bicycle which traveled down from the top of a hill would move faster than one which started moving from half-way down the same hill, but could give no reason for this phenomenon. After the lesson, the student could give a reason.

In response to question 5, sample student 1 answered correctly in the first interview that a person sliding 5 meters down a hill would be able to knock a paper box farther than one who slid for only 3 meters, but was not able to give a reason for this until the second interview. The student now understood that a longer distance would result in both greater speed and greater force.

In response to the sixth question sample student 1 initially gave the correct answer. The student believed that their father would displace more water than would the student after sliding down a water slide, but incorrectly believed that this was due to the father being larger. After the lesson though, the student realized that the higher displacement of water was due to the father's weight (mass).

The response to the seventh question was rather different. Sample student 1 correctly answered that a fat man could stop a cart rolling down a hill more easily than a thin man, but incorrectly believed this was because the fat man was both larger and heavier (volume). In the second interview the student's answer was still correct but the student did not want to venture a guess as to why this phenomenon would occur.

Sample student 1's response to the eighth question of the first interview was vague, the student was unsure whether a sixth grader being run into by a third grader running down a staircase would sustain more injuries than a first grader run into by the same third grader. However, after the lesson sample student 1 understood very clearly that the first grader would sustain greater injury, this is because the sample student now understood the relationship between weight and mass.

Case 2: Analysis of sample student #2

Sample student #2 in response to the first question said that it would be more tiring to go up the steeper hill, in both the first and the second interviews. In the first interview conducted sample student #2 was able to explain that a bicycle trip up the steep hill would be more tiring due to the steep angle, greater force of friction and greater resistive force resulting from the bicycle tires. In the second interview conducted sample student #2 was able to explain that the bicycle trip up the steep hill would be more tiring due to the steep angle of the ascent.

In response to question #2 sample student #2 indicated the belief in the first interview that a bicycle traveling down the steeper of two hills would more travel quickly than a bicycle traveling down the less-steep hill. In first interview sample student #2 was able to give a reason for question #2, the reason is that the steeper hill was taller than the less-steep hill. But in the second interview sample student #2 was able to give a better reason for the answer-previously given. The steeper hill had a larger angle and there are the bicycle would travel faster than it would down the less-steep hill.

Sample student #2 responded to question #3 in both the first and second interviews that it is faster slide down in steeper hill, sample student #2 was unable to explain why this was correct in both interview. In question #3, sample student #2 didn't build his correct conceptions.

In response to the third question sample student #2 gave the correct response in the first interview. The sample student correctly indicated that since the first slope was steeper than the second a person traveling down the first

slope would travel move quickly. The sample student then clearly made the connection that the higher speed of descent was directly related to the force with which the paper box would be kicked. The sample student's response to this question in the second interview did not, change from that given in the first interview.

In sample student 2's first and second interviews question #4 was answered correctly. The student recognized that the cart which traveled down from the top of a hill would move faster and farther than one which started moving from half-way down the same hill.

In response to question #5, sample student 2 answered correctly in the first interview that a person sliding 5 meters down a hill would be able to knock a paper box farther than one who slid for only 3 meters, but gave alternative frames. The greater distance of the slide gave the person sliding from higher up a longer lead-time to pick up speed (and therefore force) with which to kick the box farther.

In the second interview, sample student answered correctly that a person sliding five meters down a hill would be able to knock a paper box farther than one who slid for only three meters because he would be moving faster and farther from a five meter slope than he would from a three meter slope.

In response to the sixth question sample student #2 initially gave the correct answer. In the first interview, the student believed that the sample student's father would displace more water than would the student after sliding down a water slide. but was partially incorrect believing that this was due to the father's slower speed as well as the father's weight (mass). In the second interview, the student, again, was only partially correct, believing that the greater displacement of water directly correlated to the father,s greater volume but also recognizing that the father's weight (mass) was in some way related to the displacement of water.

The response to the seventh question in the first and the second interviews. Sample student #2 correctly answered that a fat man could stop a cart rolling down a hill more easily than a thin man, but incorrectly believed this was

because the fat man was heavier. The reasoning for the second interview's response that the fat man was heavier than the thin man. Sample student #2's response to the eighth question indicated that the student was applying direct experience in order to answer the question. In the first interview the sample student (a sixth-grader) responded " I would stumble and backward, but I would not fall. The other kid would fall". The student could not give a reason why this was so.

In the second interview the sample student was able to correctly correlate. The problem to the student's mass rather than to the student's age or grade level using a scientific conception method obtained from the lesson the student was able to determine that a heavier student was more likely to remain stable if run into by a lighter student.

Case 3: Analysis of sample student #3

Sample student #3 in response to the first question said that it would be more tiring to go up the steeper hill, in both the first and the second interviews. In the first interview conducted, sample student #3 believed a bicycle trip up the steeper hill. Would be of a greater distance (Although the student was initially told that the distance traveled would be the same in both cases, the student still carried a misconception that the angle of ascent corresponded to distance.) and would therefore be more tiring than that along flat ground.

However, in the second interview, the student indicated that the steeper hill would have the steeper angle and therefore the bicycle on the steeper hill would be more tiring to ride.

In response to question #2 the student indicated the belief in the first and second interviews that a bicycle traveling down the steeper of the hills would be likely to travel more quickly than a bicycle traveling down the less-steep hill.

In first interview sample student #3 was able to give a reason for question #3, the reason was that the bicycle rolling down from the steeper hill. Would have its center of gravity thrown forward. The researcher considers the above reason as an alternative frame. The real reason the bicycle rolling down the

steeper hill would travel more quickly is because it gathers greater thrust. Therefore the student appears to be applying an accurate scientific conception method in order to determine a response. The student's responses to this question in the second interview were merely more concise and to the point.

In response to the third question sample student #3 gave the correct response in both the first interview and the second interview. In the first interview, the student used the same reasoning as had been used in the response to the previous question. The center of gravity of the person on the slide would be thrust forward in the same fashion as that of the bicycle rider's , in the second interview the student was able not only to point at the connection between thrust and speed, but in addition indicated the influence of the greater angle on the speed of the person sliding down the taller slide.

Sample student #3 response to the first and the second interview, question #4 was correct. The student recognized that the bicycle which traveled down from the top of a hill would move faster than one which started moving from half-way down the same hill. In the first interview, sample student #3 could give no reasons. In the second interview, sample student #3 responded that the force of thrust gained by traveling from the top of the hill would be greater. Sample student #3's reasons were indicated the use of a scientific conception method.

In response to the sixth question, sample student #3 initially gave the correct answer. In the first interview, the student believed that their father would displace more water than would the student after sliding down a water slide. The reason given in the first interview was that the sample students' father was larger (volume). So, the sample student had misconceptions in the first interview. On the other hand, the reason given in the second interview was that the sample student's father was heavier (mass). This indicated that the sample student was now using a scientific conception method to analyze the problem.

In response to the seventh question in the first and the second interviews. Sample student #3 correctly answered that a fat man could stop a cart rolling down a hill more easily than a thin man. The reason given in the first and the second interview were that the fat man was heavier than the thin man. The sample student also responded correctly to the last question in the first and the

second interview by responding that the variable involved was weight (mass). The heavier student would remain stable while the lighter student would fall.

Case 4: Analysis of sample student #4

Sample student #4 in response to the first question said that it would be more tiring to go up the steeper hills, in both the first and the second interviews. In the first interview conducted sample student #4 said that a bicycle trip up the hill would be more tiring due to the resistance encountered on the hill. There were indicate in the above responses. It appeared that sample student #4 had previously had this kind experience. In the second interview conducted sample student #4 said that a bicycle trip up the hill would be more tiring due to larger angle of the hill versus the flat plane. The correct scientific conceptualization method was used in answering the second interview. In response to question #4 the indicated belief in the first and the second interviews was that a bicycle traveling down the steeper hill would travel more quickly than a bicycle traveling down the less-steep hill. The reasons given for the first and the second interviews' responses were that the angle of the steeper hill was greater than that of the less-steep hill. These conceptions coincided with an accurate. Scientific conceptualization of the situation.

In response to question #5 the student indicated the belief in the first and the second interviews that a person sliding down the steeper slide would travel faster than a person sliding down the less-steep slide.

The reason for the response in the first interview was that there was no resistive force, while the reason given in the second interview was that there was more gathered thrust.

Sample student #4 responded to question #4 in both the first and second interviews that sliding down the taller of two slides would result in a paper box being kicked farther. However, in the first interview. The student could only link this with force of thrust gained by sliding down a slide. In the second interview the students' response was far more concise. The angle and distance being greater on the larger slide would that the student would slide down the slide more quickly and would therefore gain greater thrust.

Sample student #4 responded to question #5 correctly. The longer distance the cart rolled down the hill the further it would roll along flat ground. The student's reasoning in the first and second interviews was that the distance traveled from the top of the hill was longer than that traveled from half-way up the hill.

The sample student also correctly responded to question #6. In this question one cart rolled a distance of five meters while other cart rolled a distance of three meters in order to strike a paper box. Although the sample student was able to correctly show in both the first and second interviews, then the cart rolling five meters could knock the box farther, the student's explanation of the relation between distance and force was clearer in the second interview.

In response to the seventh question, the sample student displayed a misconception in the first interview which still was not completely resolved in the second interview. The student indicated that their father would displace more water than would the student attributing this in the first interview to the father's greater weight and size (volume), and in the second interview to the father's greater size (volume), apparently the lesson did not succeed in relieving the student of prior misconceptions, the sample student's initial solution to the question of whether it would be easier for a fat student or a thin student to stop a rolling cart demonstrated on interesting alternative frame conception of the problem. The student reasoned that adults and fat students (large bodies) could exert greater force while children and thin students (small bodies) could only exert a little (force, therefore the fat student could exert greater force to stop the cart. By the second interview the student was able to revise this analysis and correctly identify the fat student's greater mass (greater weight) versus the thin student's lesser mass (lesser weight) would allow the fat student to more easily halt the cart.

Finally sample student #4's response to the eighth question in both the first and second interviews indicated the sample student's belief that the sixth grader's ability to exert force and the sixth grader's mass were both greater and therefore would cause the third grader to fall back (but not the sixth grader). Moreover the sample student applied this same rule to the case of the first

grader being run into by the third grade and came to the conclusion that the first grader would fall back. Clearly by the second interview the student had consolidated their ability to use a scientific conceptualization method. By then the student was also able to point out that the greater the mass a body had, the less distance it could be moved and the less mass a body had. The greater the distance it could be moved.

Case 5: Analysis of sample student #5

Sample student #5 in response to the first question said that it would be more tiring to go up the steeper hill, in both the first and the second interviews. In the first and second interview conducted, sample student #3 believed a bicycle trip up the steeper hill would be of a greater angle and would therefore be more tiring than that along flat ground.

In response to question #2 the student indicated the belief in the first and second interviews that a bicycle traveling down the steeper of the hills would be likely to travel more quickly than a bicycle traveling down the less-steep hill.

In the first interview sample student #5 was able to give a reason for question #3, the reason was that the bicycle rolling down from the steeper hill would be likely to travel more quickly than a bicycle traveling down the less steep hill. Therefore the student appears to be applying an accurate scientific conception method in order to determine a response. The student's responses to this question in the second interview were merely more concise and to the point.

In response to the third question sample student #5 gave the correct response in both the first interview and the second interview. The student was able to point at the larger angle of the steeper hill as the cause for greater speed. These two interviews demonstrated the student's ability to apply a scientific conceptualization method.

Sample student 5's responded to question about two sliding slides indicated that the student was applying a scientific conceptualization method in both the first and second interviews. The student correctly correctly indicated that kicking a paper box after sliding down the steeper of two slides would result in the box traveling farther. In the first interview the student indicated that this was due to

the greater speed and thrust gained by sliding down the steeper slide. In the second interview the student was able to communicate an even better understanding of the relation between thrust and the distance the box would travel.

Sample student #5 response to the first and the second interview, question #4 was correct. The student recognized that the bicycle which traveled down from the top of a hill would move faster than one which started moving from half-way down the same hill. In the first interview, sample student #5 responded that the force of thrust gained by traveling from the top of the hill would be greater. In the second interview, sample student #5 responded that the greater sliding distance from the top of the hill would result in faster movement at the bottom. Sample student #5's reasoning indicated the use of a scientific conceptualization method.

In response to question about two different distance sliding slides, sample student 5 answered correctly in the first interview that a person sliding 5 meters down a hill would be able to knock a paper box farther than one who slid for only 3 meters. In the first interview the student believed this was because both the force of thrust and the height of the five meter slope would be greater. In the second interview the student had refined his solution, saying the cause was the greater distance traveled.

In response to the sixth question, sample student #3 initially gave the correct answer. In the first interview, the student believed that their father would displace more water than would the student after sliding down a water slide. The reason given in the first interview was that the sample students' father was larger (volume). So, the sample student had misconceptions in the first interview. On the other hand, the reasons given in the second interview were that the sample student's father was larger (volume) and heavier (mass). This indicated that the sample student now had a new misconception regarding the volume variable.

In response to the seventh question in the first and the second interviews. Sample student #3 correctly answered that a fat man could stop a cart rolling down a hill more easily than a thin man. The reason given in the first and the

second interview were that the fat man was heavier than the thin man. The sample student also responded correctly to the last question in the first and the second interview by responding that the variable involved was weight (mass). The heavier student would remain stable while the lighter student would fall.

Case 6: Analysis of sample student #6

Sample student #6 in response to the first question said that it would be more tiring to go up the steeper hill, in both the first and the second interviews. In the first interview conducted, sample student #6 believed a bicycle trip up the steeper hill would be a more rocky trip (misconception) and would therefore be more tiring than that along flat ground.

However, in the second interview, the student indicated that the steeper hill would have the steeper angle and therefore the bicycle on the steeper hill would be more tiring to ride.

In response to question #2 the student indicated the belief in the first and second interviews that a bicycle traveling down the steeper of the hills would be likely to travel more quickly than a bicycle traveling down the less-steep hill.

In the first interview sample student #6 was able to give a reason for question #3, the reason was that the bicycle rolling down from the steeper hill, again, would have a more rocky trip. In addition the rocks and other impedances would make the trip more tiring. This response, obviously, indicated a misconception on the student's part. The real reason the bicycle rolling down the steeper hill would travel more quickly is because it gathers greater thrust. However, the student's responses to this question in the second interview were quite concise and to the point.

In response to the third question sample student #6 gave the correct response in both the first interview and the second interview. In the first interview. The sample student pointed to one slide's greater height as the cause for the greater speed. In the second interview the student was able to point at the connection between angle and speed, but in addition indicated the influence of the greater angle on the speed of the person sliding down the taller slide.

Sample student #6 response to the first and the second interview, question #4 was correct. The student recognized that the bicycle which traveled down from the top of a hill would move faster than one which started moving from half-way down the same hill. In the first interview, sample student #6 could give no reasons. In the second interview, sample student #6 responded that the force of thrust gained by traveling from the top of the hill would be greater. In addition , the student pointed out the greater distance of travel down the hill would affect the distance which the bicycle would later travel on flat land. Sample student #6's reasons were indicated the use of a scientific conceptualization method.

In the first interview the sample student answered that a paper box would be kicked farther after sliding down a slide three meters in length than the box could be kicked after sliding down a slide five meters in length. The student reasoned that this was because the mountain slope would be flatter. This represented a misconception on the student's part. In the second interview the student correctly identified the slide five meters in length as the one from which the box could be kicked farther. The student said this was because the five meter long slide was taller (hence longer). It appears that by the second interview the student was rid of a previous misconception.

In response to the sixth question, sample student #3 initially gave the correct answer. In the first interview, the student believed that their father would displace more water than would the student after sliding down a water slide. The reason given in the first interview was that the sample students' father was heavier (weight).The reason given in the second interview was also that the sample student's father was heavier (mass). This indicated that the sample student was now using a scientific conception method to analyze the problem.

In response to the seventh question in the first and the second interviews. Sample student #6 correctly answered that a fat man could stop a cart rolling down a hill more easily than a thin man. The reason given in the first and the second interviews were that the fat man had a greater mass than the thin man. The sample student also responded correctly to the last question in the first and the second interview by responding that the variable involved was weight

(mass). The heavier student would remain stable while the lighter student would fall.

Case 7: Analysis of sample student #7

Sample student #7 in response to the first question said that it would be more tiring to go up the steeper hill, in both the first and the second interviews. In the first interview conducted, sample student #7 believed a bicycle trip up the steeper hill would encounter more resistive force from the steeper hill than from the less-steep hill, it would therefore be more tiring than traveling along flat land.

However, in the second interview, the student indicated that the steeper hill would have the steeper angle and therefore the bicycle on the steeper hill would be more tiring to ride.

In response to question #2 the student indicated the belief in the first and second interviews that a bicycle traveling down the steeper of the hills would be likely to travel more quickly than a bicycle traveling down the less-steep hill.

In the first interview sample student #7 was able to give an answer for question #3. The reason was that a bicycle rolling down the steeper hill would travel more quickly because it gathers greater thrust. The reason given in the second interview was that the angle of the steeper hill was longer than that of the less steep hill.

The student's response to which of two slides with varying levels of steepness was faster to slide down correctly identified the steeper of the two slider as the one which would be faster. However, in the first interview the student misidentified the cause in the same fashion as above. The student believed the higher speed was due to a greater force of thrust. In the second interview the sample student was able to correctly apply the scientific conceptualization method provided by the lesson and could indicate that the reason for greater speed was the slide's greater angle of slope.

The student's response to the question of kicking a paper box after sliding down slides of varying heights was correct in both interview. However the student was never able to give a reason for the answers given.

Sample student #7's response to the first and the second interview, question #4 was correct. The student recognized that the bicycle which traveled down from the top of a hill would move faster than one which started moving from half-way down the same hill. In the first interview, sample student #7 could give no reasons. In the second interview, sample student #7 responded that the longer distance traveled from the top of the hill the faster the cart's speed would be. Sample student #7's reasons indicated the use of a scientific conceptualization method.

The student was never able to construct a conceptualization method to answer the question of whether a paper box would be kicked farther after sliding down a slide five meters in length or after sliding down a slide three meters in length. While the student answered correctly in both interviews that the slide from five meters would make the box go farther; the student could never say why this was so.

In response to the sixth question, sample student #7 gave the correct answer. In the first interview, the student believed that their father would displace more water than would the student after sliding down a water slide. The reasons given in the first and second interviews were that the sample student's father was heavier (mass). This indicated that the sample student was using a scientific conceptualization method to analyze the problem.

In response to the seventh question in the first and the second interviews. Sample student #7 correctly answered that a fat man could stop a cart rolling down a hill more easily than a thin man. The reason given in the first and the second interviews were that the fat man had more mass than the thin man. The sample student also responded correctly to the last question in the first and the second interview by responding that the variable involved was weight (mass). The heavier student would remain stable while the lighter student would fall.

Case 8: Analysis of sample student #8

Sample student #8's answer to the first question indicated that the student had a very clear conceptualization method for this problem. The student was immediately able to link the phenomenon (That a trip up a steep incline would be more tiring than a trip along a flat plane) to the cause (that the greater angle of ascent would make the trip more strenuous). The student's reasoning was quite effective: the steeper the incline the closer the trip came to being a vertical ascent, the less street the ascent the closer the trip came to being horizontal.

The student initial response to the second question came as a bit of a surprise. The sample student initially believed that a trip along the less-steep of two inclines would be faster than a bicycle trip down the steeper of two inclines. In the first interview the student clarified where the misconception was: when the ground is flat, it is easy to ride quickly, but when the ground is steep one cannot ride so quickly. In the second interview it became clear that the student had overcome the previous misconception. The student explicitly noted that the lesson just studied had pointed out that a cart traveling down an incline would travel more quickly because the angle of descent was greater, and therefore it was easier to travel downward.

In first interview sample student #8 was able to give a reason for question #3. The reason was that a bicycle rolling down the steeper hill would travel more quickly is because it gathers greater thrust. Therefore the student appears to be applying an accurate scientific conceptualization method in order to determine a response. The student's responses to this question in the second interview were merely more concise and to the point.

Sample student #8 response to the first interview, question #4 was incorrect. The student believed that the bicycle which traveled down from the midpoint of a hill would move the same as one which started moving from the top of the same hill. In the first interview, sample student #8 seemed to have a misconception. In the second interview, sample student #8 responded that the force of thrust gained by traveling from the top of the hill would be greater. Sample student #8's reasons indicated the use of a scientific conceptualization method.

The student was able to answer the question of whether a paper box would be kicked farther after a cart rolled down an incline five meters in length or after rolling down an incline three meters in length correctly, but in the first interview was unable to give a reason why. In the second interview the student was able to say that the cart rolling five meters would knock the box farther, because the distance rolled was longer. This indicated that the student was now applying a scientific conceptualization method to analyze the problem.

In response to the sixth question, sample student #8 gave the correct answer. In the first and second interviews, the student believed that their father would displace more water than would the student after sliding down a water slide. The reasons given in both interviews was that the sample students' father had a larger (volume) and weight (mass). So, the sample student had misconceptions involving the volume variable in both interviews.

In response to the seventh question in the first and the second interviews. Sample student #8 correctly answered that a fat man could stop a cart rolling down a hill more easily than a thin man. The reason given in the first and the second interviews was that the fat man was heavier than the thin man. The sample student also responded correctly to the last question in the first and the second interview by responding that the variable involved was weight (mass). The heavier student would remain stable while the lighter student would fall.

Case 9: Analysis of sample student #9

In response to the first question the sample student was able to indicate in both interviews that the trip up the steep hill would be more tiring than the trip along a flat plane. However, in the first interview the student attributed this to a force which would pull the student downwards.

+3

This researcher believes that the student may have been trying to describe the force of gravity, where a body under the influence of gravity on a slanted plane will yield force in the proportion: f=mgsin0 (where f= force and m= the mass of a body). The greater this force is the harder it would be to ascend a mountain. It is this researchers belief that the sample student was attempting to apply an alternative frame to explain this day-to-day phenomenon.

In the second interview the student only slightly revised the previous explanation indicating the force which made the bicycle going uphill more tiring was one which "pulled things back".

As in the first response to the first question, the sample student's response to the second question initially indicated an unresolved misconception. In the student's first interview, the student expressed the belief that the bicycle would travel more quickly down the less-steep of the two hills and attributed this to the fact that there would be less objects impeding the bicycles' path. Aside from this, the student could think of no other reason for the response. The fact that no mention of impedances in the path of either bicycles had been made by this researcher, it can only be assumed that the student was working under a misconception.In the second interview, however, the student was able to make the connection between the increased speed of the bicycle and the greater angle of descent. The student appears to have applied a scientific conceptualization method gained from the lesson in resolving a problem.

The student's response to which of two slides with varying levels of steepness was faster to slide down correctly identified the steeper of the two slides as the one which would be faster. But in the first interview the student could not say why this was the case. In the second interview the student was much clearer: the more vertical the slope the faster the bicycle would travel. The student had obviously developed a clearer picture of the situation.

The student's response to which of two slides with varying levels of steepness would allow a student to kick a paper box farther was initially correct in both interviews. But the student was never able to explain why this was the

case. It appears that the student never developed a method for formulating a "mountain slope as an angular plane" conceptual model.

When faced with the question of which bicycle would continue farther after traveling down slopes of varying lengths the sample student was, on both occasions, able to respond that the bicycle which traveled down from the mountain top would travel further upon reaching the bottom. Unfortunately, the student in the first interview attributed this to the force of gravity. The student said that there had been a lesson on gravity in the "Force and Motion" unit of the fifth-year natural science textbook. This unit made such an impression on the student that the student now attributed many of the phenomena covered in this experiment to the force of gravity. It was obvious that the students' understanding of the force of gravity was very unclear. In the second interview the student could give no other reason for the phenomenon.

Responding to the question comparing the distance a paper box would be kicked after sliding down slides of varying steepness the sample student correctly identified that the box would be kicked farther after a slide from five meters than it would after a slide from three meters. In the first interview the student indicated the belief that this phenomenon was due to the force of thrust, but in the second interview the student failed to identify that a slide down an inclined plane of greater distance would result in greater force and in this interview also failed to mention the force of thrust. It can be seen from this that the student never really managed to develop a conceptual model where “the longer the distance of descent equaled the longer the distance an object could be pushed”.

The response of sample student #9 to the question of water displacement by

the student and the student's father after sliding down a water slide also

clearly displayed use of a scientific conceptualization method. In both interviews the student indicated that the Father's greater weight was the cause for the additional water displacement.

The sample student correctly answered in both the first and second interviews

that a fat student would find it easier to stop a moving cart than would a thin student. In the both instances the student was able to point out that this was do to the fatter students' greater mass.

And in the final question, sample student #9 fully grasped that mass was the critical issue in determining who would fall if a sixth grader or a first grader were run into by a third grader running down a staircase. The student was very precise in both interviews; The greater the mass, the less distance it would move. The less the amount of mass, the further the object would move. This indicated that the student was applying a scientific conceptualization method in resolving the problem.

Case 10: Analysis of sample student #10

In response to the first question Sample Student #10 answered in both interview #1 and in interview #2 that the traveling up the steeper of the two hills would be more tiring, but in the first interview the student could not give a reason why this was true. In the second interview, however, the sample student was able to point out that because the because the angle of the incline was close to 90 degrees bicycling up it would be more tiring. It can be seen that in the second interview sample student #10 applied a scientific conceptualization method in order to come to the correct conclusion.

Sample student #10's responses to the second question looked much the same. The response was correct in both cases, a bicycle traveling down the steeper of the two slopes would travel more quickly, but in the first interview the sample student believed that the less-steep slope would make the bike travel more slowly (the student could not give a clear explanation for the problem). While in the second interview the student was able to point out that the steeper angle of descent approached 90 degrees and that a bicycle moving down it would pick up speed as it descended. Therefore it can be seen that the student had begun applying a scientific conceptualization method.

In response to the question of the slides with varying degrees of steepness, the sample student was able to answer correctly in both interviews that traveling down the steeper of the two slides would be faster, but could provide

no logical reason for this in the first interview. However, in the second interview the student was able again able to connect the steeper angle (approaching 90 degrees) with the faster speed of descent using a scientific conceptualization method.

This student's response to the question of kicking a paper box after sliding down slides of varying heights did not change between the two interviews. The student initially was able to answer that kicking the box after sliding the longer distance would make the box go farther. Unfortunately, the student was never able to explain why. It seems that the student was never able to establish a method for conceptualization for this problem.

In response to the problem of the distance a cart could move along a plain after traveling down hills of various distances, the student was able to correctly answer that the cart traveling from the mountain top would travel a longer distance and in the second interview was even able to establish an exact correlation between the distance that the cart traveled down the mountain and the distance it would roll on flat ground.

Sample Student #10 was able to answer the question regarding a cart moving a box after rolling a distance of five meters versus moving the same box after rolling only three meters correctly in both interviews, but made no improvement in explaining the cause for this phenomenon. Again, it appears that the student was unable to form a conceptualization method for this problem.

The students response to the question regarding water displacement by the student and the student's father after sliding down a slide was the same in both interviews. The student said that the father would displace more water. In the first interview the student indicated that this was due to the father's greater size (volume) as well as the father's greater weight. In the second interview the student only indicated that the displacement was due to the father's greater size (volume). It can therefore be seen that the lesson did not help to rid the student of a previous misconception.

The student's response to the question regarding whether a fat or a thin man would be able to stop a rolling cart more easily was correct in both interviews. The sample student was able to indicate that the fatter man would be able to stop the cart more easily because of his greater mass. This seems to indicate that the student was already analyzing this question using a scientific conception method.

In response to the final question. Sample Student #10 appeared to be uncertain how to answer, or even conceptualize the problem regarding a first and a sixth grade student being run into by a third grade student running down a staircase. The student said things like "...certain students could get hurt". However, by the second interview, the sample student was able to clearly indicate that the student with greater mass would be moved a shorter distance than would a student with a smaller mass. This clearly shows that the sample student had picked up a scientific conceptualization method from the lesson, which could then be effectively applied to problem solving.

Case 11: Analysis of sample student #11

In answering the first question, whether a bike trip up an incline was more tiring than one along a flat plan, sample student #11 on both occasions answered that the trip up the incline would be more tiring, but in the first interview was unable to say why. I the second interview, the sample student showed that the lesson had influenced the way the problem was conceptualized by indicating that the trip up the incline would be more tiring because the angle of ascent was greater.

Sample student #11 when faced with the problem of the speed with which a bicycle would travel down mountain slopes with varying angles of descent was able to respond in both interviews that the steeper slope would result in a faster trip, but in the first interview was unable to give any scientific reasoning for this. However, in the second interview, sample student #11 indicated an understanding of the connection between the angle of the slope and the speed of the bike. It could be seen that the student's perception of the problem had changed as a result of the information given in the lesson.

The student's response to the question comparing the speed traveling down slides of varying steepness was correct both in the first and second interviews; the steeper of the two slides would result in the faster trip. But, the student could not clarify "why" in the first interview. The student was only able to make comments indicating the steeper angle was "much more stimulating". By the second interview, though, the student could clearly link the speed of descent to the steepness of the angle of descent, thus indicating a clear conception of an angle. From this it can be seen that the content of the lesson led the student to the use of an effective scientific conceptualization method.

Responding to the question comparing the distance a paper box would be kicked after sliding down slides of varying steepness the sample student said that the steeper slide would allow the box to be kicked farther. In the first interview the sample student proved to have a misconception that the steeper the slide was the farther a person sliding down it would travel. In the second interview, however, the sample student was able to apply a scientific conceptualization method in order to analyze the problem correctly. The student said that the steeper angle of one slide would make a person travel down it more quickly and would enable that person to kick the paper box farther.

Responding to the question about a cart striking a paper box after traveling down inclines of three and five meters the sample student knew in both interviews that the cart traveling five meters would move the box farther and, in the first interview was able to correctly point to the force of thrust being the cause for this phenomenon. The student said that because the distance of slide was longer the speed of the cart would therefore be greater. With the speed being greater the force of thrust would also be greater. In the second interview the student was able to state the concept even more concisely: "The longer the distance of the slide, the farther the box will be moved".

The sample student's response to the question of the traveling distance of a cart rolling from the top and from the midpoint of the same mountain, again, indicated a very clear conceptualization of the problem. The student's answer to the second interview also indicated that the lesson content had further enabled

the student to explain the phenomenon. The student said: "The longer the distance of the slide, the farther the object will continue to roll".

The response of this sample student to the question of water displacement by the student and the student's father after sliding down a water slide also clearly displayed the use of a scientific conceptualization method. The student was able to clearly state, in both interviews, that the greater water displacement was the direct result of the father's greater mass.

In response to the question of a fat and a thin student's ease in stopping a rolling cart, the student was able to correctly answer, both times, that the fatter student would be able to stop the cart more easily and in the second interview was able to very succinctly explain that the greater the student's mass the more easily the student could stop the rolling cart.

Responding to the question of a first and sixth grader being bumped into by a third grader running down a stair case in the first interview, the sample student's response was unfortunately not to the point. The student clearly did not grasp the connection between the relative masses. But in the second interview the sample student very clearly understood the relationship between the students of varying mass. The student clearly understood that the greater the mass of a body the less distance that body could be moved and the less mass a body had the greater distance that body could be move. It could be clearly seen that the student had gained a clearer picture of the situation as the result a the lesson the student had taken.

Case 12: Analysis of sample student #12

In response to the first question the sample student was able to indicate in both interviews that the trip up the steep hill would be more tiring than the trip along a flat plane. However, in the first interview the student attributed this to the force of gravity. Moreover the student's application of this concept was (like 9 of the other subjects in this study) very vague.

A body under the influence of gravity on a slanted plane will yield force in the following proportion: f=mgsin0 , the greater this force is the harder it is to ascend a mountain.

By the second interview the student had grasped the connection between the angle of ascent and the level of difficulty. Therefore showing that the lesson had provided the student with a method for scientific conceptualization of the problem.

As in the first response to the first question, the sample student's response to the second question indicated an unresolved misconception. The student believed that gravity was responsible for a bicycle traveling more quickly after traveling down the slope of the steeper of two hills. While the student understood which bicycle would travel more quickly the student was not able to give the correct cause for this phenomenon until the second interview. The student was then able to connect the increased speed to the greater angle of descent. Thus the student again applied a scientific conceptualization method gained from the lesson in resolving a problem.

The student's response to which of two slides with varying levels of steepness was faster to slide down correctly identified the steeper of the two slides as the one which would be faster. But in the first interview the students answer was not very accurate: The flat (surface) has movement over a shorter distance, the steeper (surface) has movement over a longer distance. Why this was the case the student could not explain. But in the second interview the student was much clearer: the speed is greater because the force of thrust is greater and the slide is longer. While not perfect, the student had obviously developed a clearer picture of the situation.

The student's response to which of two slides with varying levels of steepness would allow a student to kick a paper box farther was initially correct in both interviews. The student knew that the box kicked after sliding down the steeper of two slides would go farther. But in the first interview the student was unable to say why this was so. In the second interview, though, the student was quite clear as to the answer. The angle of descent being steeper, the speed of the slide would be faster and the force of the thrust greater.

When faced with the question of which bicycle would continue farther after traveling down slopes of varying lengths the sample student was, on both occasions, able to respond that the bicycle which traveled down from the mountain top would travel further upon reaching the bottom. Unfortunately, the student, in both the first and second interviews, failed to give the correct reason for this phenomenon. In both interviews the student mistakenly attributed this phenomenon to a greater force of thrust.

The student was able to finally apply a scientific conceptualization method in answering the question of whether a paper box would be kicked farther after sliding down a slide five meters in length or after sliding down a slide three meters in length. The student answered in both the first and second interviews that the slide from five meters would make the box go farther but until the second interview was not able to indicate that this was because of the greater distance of descent.

The student was also able to answer the question of whether the student's father or the student would displace more water after sliding down a waterslide correctly in both the first and second interviews. The student recognized that the father would displace more water. The student was also able to give the correct reason in both cases "Because father's weight is heavier". It appears that the student was already capable of applying a scientific conceptualization method to resolve this problem.

The sample student correctly answered in both the first and second interviews that a fat student would find it easier to stop a moving cart than would a thin student. In the first interview the student, applying an alternative frame, said that this was the heavier student had greater force but in the second interview more precisely indicated that the fatter student was heavier (had more mass).

And in the final question, sample student #12 was already able to grasp that mass was the critical issue in determining who would fall if a sixth grader or a first grader were run into by a third grader running down a staircase. In the second interview, though, the sample student was able to elaborate much

further. The fatter student had greater mass and would probably knock down the smaller student. If the student was thinner then they would probably be knocked down. The student clearly understood that the body with greater mass would be moved less than would a body of lesser mass.

Case 13: Analysis of sample student #13

In response to the first question Sample Student #13 answered in both interview #1 and in interview #2 that the traveling up the steeper of the two hills would be more tiring. In the first interview the sample student indicated the belief that this was because even though the bicycle was traveling uphill the center of gravity (for the bike) was pointing downhill. It is obvious that the student did not have a grasp on the true cause. But in the second interview the student was able to point out the cause of was the difference in angle. It can be seen that in the second interview sample student #13 applied a scientific conceptualization method in order to come to the correct conclusion.

Sample student #13's responses to the second question was correct in both cases, a bicycle traveling down the steeper of the two slopes would travel more quickly. However, in the first interview the student attributed this to the force of gravity. Why gravity was responsible the student really could not explain. The student's application of this concept was similar to that of 9 of the other subjects in this study.

A vehicle under the influence of gravity on a slanted plane will yield force in the following proportion: f=mgsin0. The manner in which these students tried to apply gravity to the problem seemed to indicate a misconception rather than an alternative frame.

By the second interview the student had grasped the connection between the angle of ascent and the level of difficulty. Therefore showing that the lesson had provided the student with a method for scientific conceptualization of the problem.

In response to the question of the slides with varying degrees of steepness, the sample student was able to answer correctly in both interviews that

traveling down the steeper of the two slides would be faster, but, again, tried to attribute this to the force of gravity in the first interview. However, in the second interview the student was able again able to connect the steeper angle with the faster speed of descent using a scientific conceptualization method.

This student's response to the question of kicking a paper box after sliding down slides of varying heights in the two interviews was correct. The student initially was able to answer that kicking the box after sliding the longer distance would make the box go farther. Unfortunately, in the first interview, the student was unable to explain why. But by the second interview the student had picked up the skill necessary to show that the cause of the phenomenon was the greater angle of the incline.

In response to the problem of the distance a cart could move along a plain after traveling down hills of various distances, the student was able to correctly answer that the cart traveling from the mountain top would travel a longer distance In the first interview the student attributed this to greater force of thrust. In the second interview the student explained that the cart traveling from the top of the hill traveled a greater distance, but then added that the slope was somehow steeper. This indicated that the student had developed a misconception. Therefore, although the student's answer contained the seeds of truth, the student's response indicated that the student still did not view the problem using a scientific conceptualization method.

Sample Student #13 was able to answer the question regarding a cart moving a box after rolling a distance of five meters versus moving the same box after rolling only three meters correctly in both interviews, but in the first interview could not explain the cause for this phenomenon. In the second interview, though, the student immediately was able to say that the box would travel farther because of the greater length of the descent. The student was now applying a scientific conceptualization method.

The students response to the question regarding water displacement by the student and the student's father after sliding down a slide was the same in both interviews. The student said that the father would displace more water. In the first interview the student indicated that this was due to the father's greater size

(volume) while in fact, it was due to the father's greater weight (mass). Thus the student had a misconception. In the second interview the student indicated that the displacement was due to the father's greater weight (mass). It can therefore be seen that the lesson helped to rid the student of a previous misconception.

The student's response to the question regarding whether a fat or a thin man would be able to stop a rolling cart more easily was correct in both interviews. In the first interview the sample student indicated that the fatter man would be able to stop the cart more easily because of his greater size (volume), his greater strength and his greater surface area. The correct answer being mass, it can be seen that these other items indicate a misconception of the problem. But in the second interview the student knew, the cart was easier to stop for the person with the greater mass.

In response to the final question. Sample Student #13 never really succeeded in conceptualizing the problem regarding a first and a sixth grade student being run into by a third grade student running down a staircase. In the first interview the student mentioned that the weight of the students might be an issue but then seemed to believe that all of the students would be affected in much the same way. In the second interview the student still failed to make a connection between the masses of the heavier and lighter students involved. It appears that the lesson did not help the student to establish a method for conceptualizing the problem scientifically.

Case 14: Analysis of sample student #14

In response to the first question the sample student was able to indicate in both interviews that the trip up the steep hill would be more tiring than the trip along a flat plane. However, in the first interview the student attributed this to the force of gravity. Moreover the student's application of this concept was (like 9 of the other subjects in this study) very vague.

A body under the influence of gravity on a slanted plane will yield force in the following proportion: f=mgsin0, the greater this force is the harder it is to ascend a mountain.

It became clear by the second interview that this was a misconception which the student was unable to get rid of.

As in the first response to the first question, the sample student's response(like that of sample student #12) to the second question indicated an unresolved misconception. The student believed that gravity was responsible for a bicycle traveling more quickly after traveling down the slope of the steeper of two hills. While the student understood which bicycle would travel more quickly the student was not able to give the correct cause for this phenomenon until the second interview. The student was then able to connect the increased speed to the greater angle of descent. Thus the student again applied a scientific conceptualization method gained from the lesson in resolving a problem.

The student's response to the question comparing the speed traveling down slides of varying steepness was correct both in the first and second interviews; the steeper of the two slides would result in the faster trip. But, the student in the first interview the student again attributed this to the force of gravity. The student continued to rely on this misconception in the second interview as well. This researcher was struck by this students inability to make any forward steps within the scope of this research project.

Responding to the question comparing the distance a paper box would be kicked after sliding down slides of varying steepness the sample student said that the steeper slide would allow the box to be kicked farther. However, in the first interview the sample student was unable to indicate why this was the case. In the second interview, though, the student was able to say that this was due to the greater force of thrust. This change between the two interviews seems to indicate that the student had previously lacked a method for conceptualizing the problem.

In response to the problem of the distance a cart could move along a plain after traveling down hills of various distances, the student was able to correctly answer that the cart traveling from the mountain top would travel a longer distance. In the first interview the student attributed this to a greater force of inertia. In the second interview the student explained that the cart traveling from the top of the hill traveled more quickly and that the force of thrust was

greater. While the actual reason is that the distance traveled is greater, it appears that the student was able to more clearly conceptualize and explain the problem after the lesson.

Responding to the question about a cart striking a paper box after traveling down inclines of three and five meters the sample student knew in both interviews that the cart traveling five meters would move the box farther and, in the first interview indicated that this was due to the greater force of inertia. This greater force of inertia would cause resistance to be greater. In the second interview the student the student indicated that as the cart reached the bottom of the hill it would travel more and more slowly. So, in the first interview the student student's answer contained some logical reasoning for the response. Since the speed of the wagon rolling from five meters is greater than that of the wagon rolling from three meters the force of inertia will be weaker and the force of thrust will be greater. But in the second interview it became obvious that the student was only able to point out that the farther a wagon traveled, once it reached the bottom, the slower it would go. It was at this point that it became clear that the student was applying a misconception in order to answer the problem.

The response of this sample student to the question of water displacement by the student and the student's father after sliding down a water slide also clearly displayed some use of a scientific conceptualization method. The student, in the first interview, pointed at the Father's greater weight as a cause for the phenomenon, but the student also mentioned inertia. In the second interview the student again was able to point to mass as one of the causes but also mentioned a force of thrust.

In response to the question of a fat and a thin student's ease in stopping a rolling cart, the student was able to correctly answer, both times, that the fatter student would be able to stop the cart more easily. In the first interview responded that the heavier students physical strength was greater. Since the correct answer should be "the heavier student's greater mass" the sample student's response indicates a misconception. In the second interview sample student #14 explicitly pointed out that the same experiment had been talked

about in his science textbook and was then able to point directly to the heavier student's mass as the cause of the phenomenon.

Responding to the question of a first and sixth grader being bumped into by a third grader running down a stair case in the first interview, the sample the sample student clearly did not grasp the connection between the relative masses. But in the second interview the sample student clearly understood the relationship between the students of varying mass. The student clearly understood that the heavier student would probably knock down the thinner student and that the thinner student would most likely be the one knocked down. It appeared that the student had gained a clear scientific conception of the relationships between bodies of different mass from the course materials presented.

DATA SUMMARY

Fourteen sample students were used in this study. The researcher analyzed the percentages of the various answers in order to discover trends. In many cases students used more than one conceptual model in their responses. Therefore a percentage of greater 100% was often arrived at. In comparing the data of the first and second interviews, the researcher found a good many preconceptions, naive conception, alternative frames and misconceptions but also found that many of these had disappeared by the second interview. A brief summary of some of the data gathered as a result of this project are listed below:

Question I(a): Results of first interview: Responses using a scientific conceptualization method (28.4%), Misconceptions (7.1%). Results of second interview: Responses using a scientific conceptualization method (67.1%), Misconceptions (7.1%)

Question I(b) :Results of first interview: Responses using a scientific conceptualization method (21.3%), Misconceptions (50%). Results of second interview: Responses using a scientific conceptualization method (100%), Misconceptions (0%)

Question I (2)(b):Results of first interview: Responses using a scientific conceptualization method (14.3%), Misconceptions (7.1%).Results of second interview: Responses using a scientific conceptualization method (57.1%), Misconceptions (7.1%)

Question I (2) (c): Results of first interview: scientific conceptualization method (64.3%), misconceptions (7.1%). Results of second interview: scientific conceptualization (85.8%), misconception (0%)

Question II (1): Results of first interview: scientific conceptualization method (35.4%), misconceptions (0%). Results of second interview: scientific conceptualization (64.3%), misconception (14.3%)

Question II (2): Results of first interview: scientific conceptualization method (71.4%), misconceptions (21.4%). Results of second interview: scientific conceptualization (100%), misconception (0%)

Question II (3): Results of first interview: scientific conceptualization method (100%), misconceptions (0%). Results of second interview: scientific conceptualization (100%), misconception (0%)

Question III (2): Results of first interview: scientific conceptualization method (85.4%), misconceptions (42.9%). Results of second interview: scientific conceptualization (85.7%), misconception (28.6%)

Question IV (1): Results of first interview: scientific conceptualization method (42.9%), misconceptions (71.4%), . Results of second interview: scientific conceptualization (85.8%), misconception (7.1%)

Question IV (2): Results of first interview: scientific conceptualization method (14.2%), misconceptions (28.4%). Results of second interview: scientific conceptualization (14.2%)

CONCLUSIONS

This study took approximately 1 year to complete. The tasks completed during that period included: a pilot study, interview question design, the first and

second interviews, and coalation of the data. From this study the following conclusions have been drawn:

(1) In most cases, the reasoning in the second interview tended to reflect the use of more scientific conceptualization methods than in the first interview. For example: in the first interview students would notice that the hills' incline approached 90 degrees , but in the second interviews the students tended to point out that the mountain was taller, had a greater angle, or that the force of thrust force was greater.

(2) The researcher found that in the second interview students often transferred information which they had gotten directly for the textbook which they had used to study the lesson.

(3) Preconceptions: Students would often apply preconceptions in an attempt to explain a phenomenon. Often these preconceptions were bits of information gathered earlier in their education which "sounded scientific " but in the context of the interview often weren't. A good example of this was the students use of gravity garnered from the "Force and Motion" unit of their fifth grade science course.

Alternative frames: A number of sample students used alternative frames; e. g., concepts drawn from the student's daily experience. These conceptions are often misused to try and explain a scientific phenomenon either wholly or partially.

(4) Misconceptions: In responding to the question about who would displace more water, many of the students had the misconception that the Father's size was the determining factor in explaining why the Father would displace more water.

(5) The ratio of students answering the questions correctly between the first and second interviews clearly indicates that the majority of the students did gain an accurate conceptualization methodology as a result of studying the lesson.

(6) All 14 sample students were between the ages of 11 and 12 years old. According to Piaget's theory, the period from 6 years of age to 11 or 12 years of age is the child's concrete operation period and from 11 or 12 years of age to 16 years of age is the child's abstract thinking operation period. There were 34 misconceptions found in the first interview's responses, but only 8 misconceptions found in the second set of interview responses. Because all of the phenomena discussed were of the concrete operation variety during the learning of this science lesson, this therefore coincides with Piaget's theory. In addition, the six students with the most misconceptions were from suburban or rural areas. These were students who were less culturally stimulated than the others, and this researcher believes that this is why they had more misconceptions. The data for this assertion was collected as a result of this study, but due to space restrictions will have to remain the subject for a later paper. Some misconceptions are not easy to remedy even through experimental activities. For example: On one problem 6 students had misconceptions but after studying the science lesson only 2 students had rid themselves of the misconception. The researcher of this paper plans to apply the results of this current study to do future research of remedial teaching strategies for resolving misconceptions of elementary school science students.

REFERENCES

Ausubel, D. P., Novak, J. D. & Hanesian, H. (1978). Educational psychology: A cognitive view (2nd ed.) New York: Holt, Rinehart.

Blosser, Patricia E. (1987). Science misconceptions research and some implications for the teaching of science to elementary school students ERIC/SMEAC Science Education Digest.

Brown, D. (1987). Using analogies and examples to help students overcome misconceptions in physics: A comparison of two teaching strategies. Dissertation Abstracts International, 49, 473A. (University of Microfilms No. 8805897).

Brown, D. , & Clement, J. (1987). Misconceptions concerning Newton's law of action and reaction: The underestimated importance of the third law. In J. D. Novak (Ed.), Proceedings of the second international seminar, misconceptions and educational strategies in science and mathematics (Vol. 3, pp. 39-53).

Brown, D. , & Clement, J. (1989). Overcoming misconceptions via analogical reasoning: Abstract transfer versus explanatory model construction. Instructional Science, 18, 237-261.

Brown, D. E. (1992). Using examples and analogies to remediate misconceptions in physics: Factors influencing conceptual change Journal of Research in Science Teaching. 29(1), 17-34.

Clement, J. (1982). Students' preconceptions in introductory mechanics. American Journal of Physics, 50, 66-71

Helm, H. & Novak, J. D. , Eds. (1983). Proceedings of the International Seminar on Misconceptions in Science and Mathematics. Ithaca, NY: Department of Education, Cornell University.

Lawson, A. & Renner, J. W. (1989). Piagetian theory and biology teaching. American Biology Teacher. 37(6), 336-343.

McDermott, L. (1984, July). Research on conceptual understanding in mechanics. Physics Today, 37, 24-32.

Novak, J. D. (1980). learning theory applied to the biology classroom. The American Biology Teacher, 42(5), 280-285.

Novak, J. D. , & Gowin, D. B. (1984). Learning how to learn. Cambridge University Press.

Piaget, J. (1952). The Origin of intelligence in children. New York: International Universities Press.

Sjoberg, S., & Lie, S. (1981). Ideas about force and movement among Norwegian pupils and students (Tech. Rep. No. 81-11). Oslo, Norway: University of Oslo.