A Description of American Students' Intuitive Ideas About "Water in the Atmosphere" at Fifth–, Eighth–, Eleventh– Grades, and College Level

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Introduction

Many research studies in science education have attempted to identify students' intuitive ideas and their characteristics during the last decade(Novak, 1987). One of the major sources of such effort was the awareness of intuitive ideas as a critical barrier to science learning(Driver, Guesne, & Tiberghien, 1985). Generative Model of Learning(Wittrock, 1974)has been identified as a possible means of explanation for the effect of prior knowledge on science learning(Happs, 1983; Osborne & Wittrock, 1985). According to Generative Model of Learning, prior knowledge in long term memory(i.e., cognitive structures) influences the selection and processing of new information. Students' cognitive structures differ from those of scientists in that the former are more loose, hence lack formalism, and have undifferentiated ideas and insufficient linkages than the latter. Kim(1990) suggested the term, Intuitive ideas, in a sense that not all prior knowledge will be activated from the long term memory in the face of new information. An intuitive idea means a part of prior knowledge accessible to a student depending upon the context.

Water in the atmosphere is one of the concepts frequently dealt with from elementary to high school science. Students interact with water and water in the atmosphere from very early age, hence there is very high probability of construction and reconstruction of intuitive ideas about it. Furthermore, water in the atmosphere is closely associated with other important science concepts such as weather, weather forecasting, climate, state changes, and the particulate nature of matter.

There have been several studies dealing with some part of the concept: state change of water(Osborne & Cosgrove, 1983), heavy rainfall(Stevens, Collins & Goldin, 1979), and water cycle(Bar, 1989). Osborne and Cosgrove interviewed 43 students ranging in age eight to seventeen years, and administered a follow-up written test to 725 students 12 to 17 years of age to investigate students' intuitive ideas about boiling of water, evaporation, condensation, and the melting of ice in the kitchen situation. They found that students held ideas about the changes of state of water which are quite different from the views of scientists.

Stevens et al.(1979) examined the types of intuitive ideas among students and their understanding of rainfall. They reported sixteen intuitive ideas. Some of them showed patterns such as sponge pattern: absorption-by-expansion, condensation by squeezing, and so forth.

Bar(1989) interviewed 300 Israeli students ranging from kindergarten to grade nine about the water cycle, including notions of evaporation, the source of clouds, and the mechanism of rainfall. Four to eight common views were identified for the sub-concepts. Bar suggested a framework based upon the understanding of conservation of air and water. Bar also articulated the shift of children's ideas about the water cycle to available knowledge accessible to the child when interviewed.

None of the above studies investigated students' intuitive ideas about water in the atmosphere systematically in a meteorological or an everyday context. Considering the close relationships and reciprocal interactions among related concepts, key concepts and their relationships should be identified and intuitive ideas should be investigated against such a network of concepts.

The main purposes of the study are to: (a) identify and describe various students' intuitive ideas and their characteristics about "water in the atmosphere"; and(b) identify the patterns of change of students' intuitive ideas about water in the atmosphere across grade and ability levels.

Research Procedures and Design

The study was conducted in three stages: a preliminary investigation, a pilot study, and the main study(Fig. 1).

Preliminary Investigation

A seventh-grader from Austin Metropolitan Area, Texas was interviewed about the following selected six earth science concepts during Fall, 1988: glaciers, groundwater, mountain building, magma, water in the atmosphere, and weather. Many intuitive ideas were identified as a result of the interviews(Kim, 1989). One concept, "water in the atmosphere", was selected for an in-depth study.

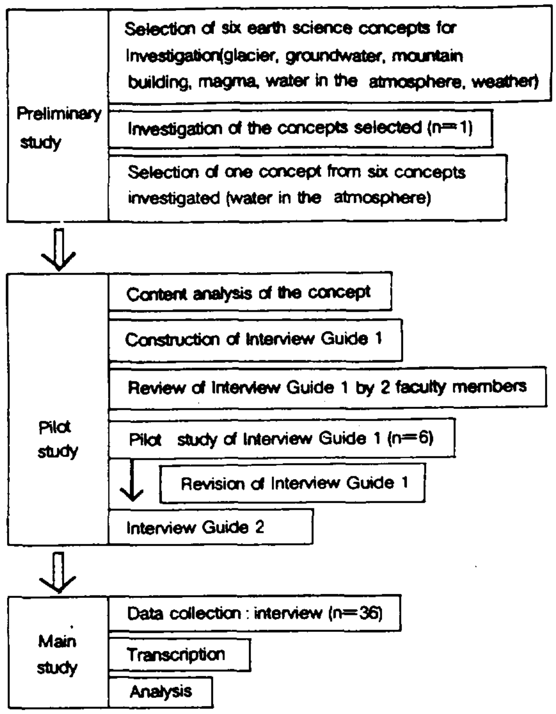


Fig. 1 The research procedures of the study

Pilot Study

The concept of "water in the atmosphere" was content analyzed by identifying and representing important sub-concepts and linkages among sub-concepts(Fig. 2). The seven sub-concepts identified were water vapor, humidity, evaporation, condensation, sublimation 1, sublimation 2, and dew point. Sublimation from a gas to a solid was referred to as sublimation 1; and sublimation from a solid to a gas was referred to as sublimation 2.

A guide, Interview Guide 1, was constructed based upon the results of content analysis and was reviewed by two faculty members at the Science Education Center, The University of Texas at Austin. Interview Guide 1 consisted of two sections: a question and a picture section. The picture section had two sets of pictures, dew and frost. The question section contained four sets of questions regarding condensation, sublimation 1, evaporation, and sublimation 2. Water vapor, humidity, and dew point were expected to be discussed during interviews.

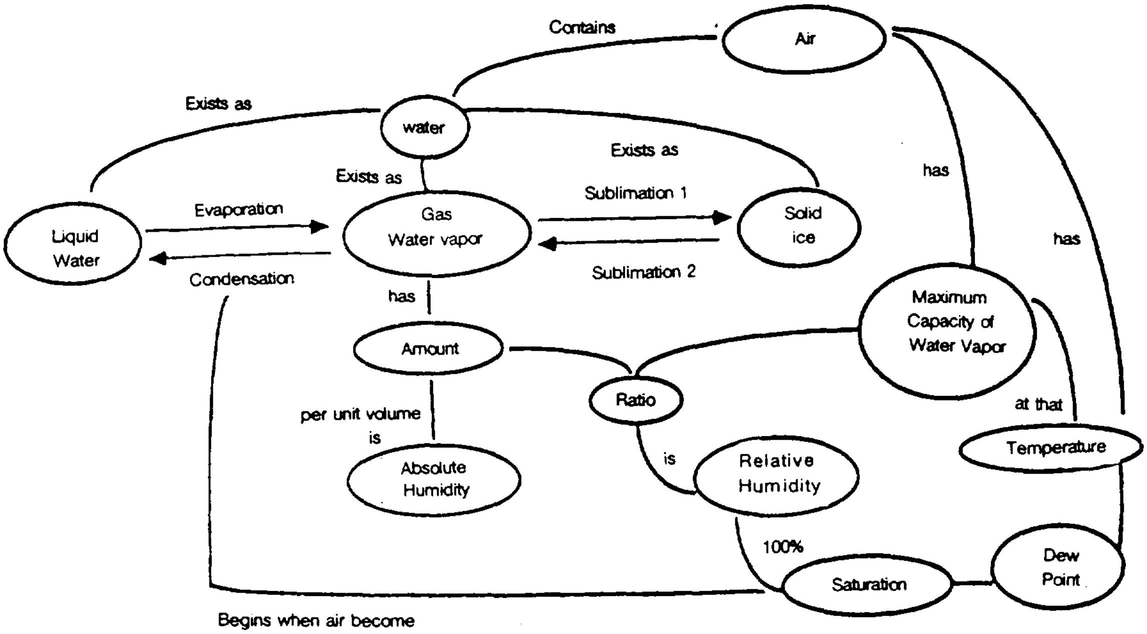


Fig. 2 Concept : "water in the atmosphere"

During February and March, 1989, Interview Guide 1 was pilot tested to determine whether the planned procedures actually produce analyzable data. A total of six subjects(one third-, one fourth-, one ninth-, one eleventh-graders, and two graduate students) were interviewed. The results showed Interview Guide 1 was quite flexible in that a wide range of subjects could understand the questions and provide their intuitive ideas in response. However, most of the subjects usually did not spontaneously provide information about humidity and dew point.

The revision of Interview Guide I was begun during the pilot study and completed shortly thereafter and resulted in the development of Interview Guide 2.

Main Study

Subjects

To grasp the dynamic nature of students' intuitive ideas, a cross-sectional sampling design was used. Four volunteer teachers from the Austin Metropolitan Area in Central Texas selected 27 subjects for the study-(nine subjects in each grade : 5th-, 8th-, 11th-grades), and each grade level included three above-average, three average, and three below-average students. The teachers were interviewed by the researcher after interviewing the subjects regarding their criteria for selecting subjects. Most of the teachers selected subjects based upon science achievement and their students' response during classroom interactions. Nine college students volunteered from The University of Texas at Austin.

Nine fifth-grade subjects were selected from four science classes of an elementary school located in a suburban part of Austin, largely a middle class community. All of nine fifth-graders had the same science background. They learned about weather, warm and cold fronts at the beginning of the school year.

Nine eighth-graders were selected from earth science classes of two schools in Austin Metropolitan Area. Six of them were selected from a special school for at-risk students, and the other three were from regular junior high school. The nine eighth-grade subjects had similar science backgrounds.

Nine eleventh-graders were selected from five geology/marine science classes in a high school in a suburban area in Austin. Most students were from middle class families. Most of the subjects had similar science background such as life science, earth science, physical sciences, and geology/marine science.

Nine college students were volunteered from The University of Texas at Austin. Three volunteer subjects were selected from each of the three groups: geology majors, mathematics concentration students in an elementary education mathematics methods class, and preservice elementary teachers in a science methods class. Three geology majors had similar science background including high school physics, chemistry, biology, and about 40 credit semester hours of geology in college. The other six subjects had taken three or four science courses in college.

Instruments: Interview Guide 2

Interview Guide 2 consisted of two major sections, a question and a picture section. The picture section contains six pages of pictures about dew, frost, a small room, an electric heater, a humidifier, and a weatherman. The question section includes sets of questions about condensation, evaporation, sublimation 1, sublimation 2, a small room, and finally weather forecasting.

Procedures of Main Study

Clinical Interviews were conducted during march, April, and May, 1989 at the schools participating in this study. The interviews were conducted following Interview Guide 2 and took about 30 to 50 minutes. The complete interview was audio-tape recorded for further analysis at a later time.

The recordings were transcribed(Gilbert, Watts, and Osborne, 1985) during March, April, May, and June, 1989. The transcriptions were analyzed during May and June, 1989. First, the intuitive ideas and thought patterns of each subject were identified for each of the seven sub-concepts. Significant classes of intuitive ideas and their properties were identified from the responses of individuals. The linkages among common intuitive ideas for each sub-concept were sought by comparing them one another in terms of their individual ideas, organizations, and interconnectedness among individual ideas. As a result, classification scheme of intuitive ideas were constructed. Indentification of developmental patterns of intuitive ideas across grade level were sought for each subconcept and as a whole. At the same time, distribution patterns of intuitive ideas across designated ability level were also sought for each sub-concept and the concept in general.

Results

Three to seven common intuitive ideas shared by a group of subjects were recognized for each of the sub-concepts. The characteristics of each common intuitive ideas, developmental patterns, and distribution patterns across ability levels identified are described below.

Common Intuitive Ideas

Water vapor

Four common intuitive ideas were identified and named as WV-Notion 1,2,3 and 4 in a sequence of sophistication. WV-Notion 1 refers to the belief that water vapor is air or part of air before it became dew or after it evaporated.

WV-Notion 2 implies that water vapor is moisture, humidity, dew, evaporation, or evaporated water in the air. The subjects who held WV-Notion 2 believed that moisture in the air is different form water in the dew in the amount(smaller), and the degree of condensation-(less condensed or thinner). The subjects who held WV-Notion 2 seemed to believe that the moisture or water in the air was still in a liquid state.

The subjects who held WV-Notion 3 believed that water vapor was gas particles, gas molecules, or hydrogen and oxygen molecules in the air. They also believed that water became separated into different gas particles such as hydrogen and oxygen or just gas particles.

The subjects whose responses are classified as WV-Notion 4 identified water vapor as water vapor, separated water molecules, or the gaseous state of water.

Humidity

Six common intuitive ideas about humidity were identified, and labeled as H-Notion 1,2,3,4,5 and 6, in a sequence of sophistication. The subjects whose responses were categorized as H-Notion 1 were not confident about the meaning of humidity.

H-Notion 2 refers to the belief that humidity is warm, heat, part of temperature, sticky, or has less air circulation. These subjects constructed their notion about humidity from their direct experience or feeling in their everyday lives.

H-Notion 3 implies that humidity is water, or moisture in the air. These subjects used the terms, humidity and moisture in the air, interchangeably. It appeared that the subjects in this category were aware of the cause of sticky feelings when it was humid.

The subjects who held the H-Notion 4 believed that humidity was the amount of water in the air. This notion seemed to be very similar to that of absolute humidity in a sense that they perceived humidity in terms of the amount of water vapor in the atmosphere.

The responses reflected in H-Notion 5 are a combination of H-Notion 4 and the relative humidity notion. These subjects could state the definition of relative humidity. However, they still subscribed to the idea that humidity is the amount of moisture in the air. For example, when asked, "What will happen if the amount of water vapor is the same but the temperature is changed?", the subjects still responded with the notion that if the amount of water vapor was the same then the humidity was also the same.

The subjects who held the H-Notion 6 correctly demonstrated a thorough understanding of relative humidity. They articulated the definition of relative humidity. At the same time, these subjects understood the effect of temperature on relative humidity. For example, increased temperature would lower the humidity because air could hold more water vapor at higher temperatures.

Evaporation

Six notions were identified about evaporation, and named as E-Notion 1,2,3,4,5, and 6 in a sequence of level of sophistication. E-Notion 1 referred to the belief that after sun rise, water drops to the ground and goes into the soil. Evaporation to these subjects meant that water went into the soil, ground, or plants.

E-Notion 2 illustrated the simplest process of evaporation. The subjects who held E-Notion 2 believed that dew rose up to the clouds or sky. However, in spite of repeated probing they never went beyond this simple explanation.

The subjects whose responese were categorized into E-notion 3 believed that evaporation was the water changed into moisture, gas, or water vapor and rose up.

The subjects who held E-Notion 4 believed that evaporation was the process of breaking up water or separating it. Some subjects stated that hydrogen and oxygen molecules were separated from each other. Others believed that water vapor broke up from water.

E-Notion 5 referred to the subjects' belief of a molecular level explanation of evaporation. As the temperature rose molecules or atoms moved faster or became excited, and escaped to a gaseous state.

The subjects whose response were classified as E-Notion 6 correctly described how dew evaporated. As temperature rose the attraction between molecules would break up. At the same time air could hold more water as the temperature rose, hence evaporation occurred.

Condensation

Seven common notions were identified about condensation, and labeled as C-Notion 1,2,3,4,5,6, and 7 in a sequence of level of sophistication. The subjects who held C-Notion 1 could not explain the process of condensation.

The subjects whose responses were classified as C-Notion 2 believed that dew was formed by clouds coming down as fog, mist, or drizzle or bursting of the cloud because it was full of water.

The subjects who believed C-Notion 3 explained the process of condensation as one by which the water in the air is driven down by cool air currents because cold air sinks and warm air rises.

C-Notion 4 referred to the belief that water vapor or moisture is condensed or combined in the air and then comes down to the ground as it is now bigger and heavier.

C-Notion 5 was described as water in the air that combines or is gathered together on the grass.

The subjects who held C-Notion 6 believed that the difference in temperature, that is, warm air and cold objects interacted and formed dew.

C-Notion 7 referred to the belief that as the temperature dropped, the air reached dew point and became saturated. Hence condensation occurred on the surface of the objects. The molecules lost kinetic energy, moved slower, became attracted.

Sublimation 1

Three notions were identified about sublimation 1, and were named as S1-Notion 1, 2 and 3 in a sequence of sophistication. S1-Notion 1 referred to the belief that water was frozen in the air, fell to the ground, and collected on the plants.

The subjects who held S1-Notion 2 believed that water or dew on the plants was frozen. The subjects who held S1-Notion 1 or 2 believed that gas went into the liquid state and then became the solid state.

The subjects who believed in S1-Notion 3 correctly described the formation of frost. They believed that water vapor changed directly to frost.

Sublimation 2

Five notions were identified about sublimation 2, and labeled as S2-Notion 1,2,3,4, and 5 in a sequence of level of sophistication. S2-Notion 1 referred to the belief that after sun rise frost would melt and soak into the soil and then remain in the soil.

The subjects who held S2-Notion 2 believed that after sun rise the forst would melt and evaporate. When the temperature rematined below freezing point the frost would still melt and evaporate slowly.

The subjects who believed in S2-Notion 3 held the similar view with S2-Notion 2, that is, after sun rise frost would melt and evaporate. However, they also believed that frost would remain if the temperature was constantly held below the freezing point.

The subjects whose responses were classified as S2-Notion 4 believed that frost would change directly into water vapor. When the temperature was below freezing point frost would not change its state.

S2-Notion 5 is similar to S2-Notion 4 in that after sun rise frost would change directly to water vapor. However, S2-Notion 5 indicated a more thorough understanding. These subjects believed that below the freezing point, frost would sublimate depending on the humidity of the air.

Dew Point

Four notions about dew point were identified, and named as DP-Notion 1,2,3 and 4 in a sequence of level of sophistication. The subjects whose responses were classified as DP-Notion 1 did not understand dew point. DP-Notion 2 referred to the belief that dew point was the time of dew formation. the subject who held DP-Notion 3 believed that the dew point was the amount of dew present in the morning. The subject who believed in DP-Notion 4 realized that dew point was the temperature at which the dew began to form.

Summary

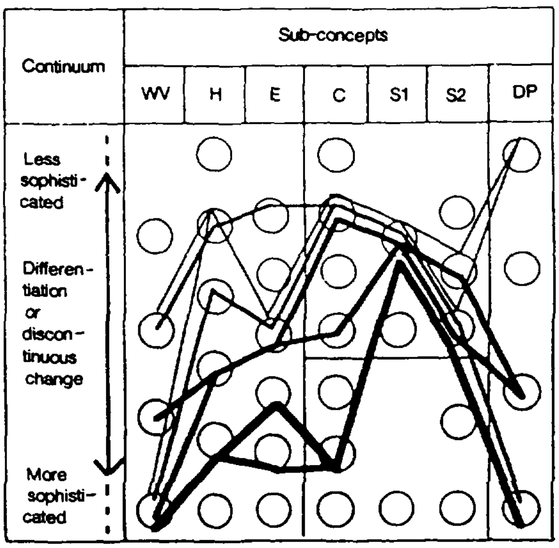
The notions of each of the sub-concepts were arranged on the less-to more-sophisticated continuum in a sequence of level of sophistication. The intuitive ideas which include direct experiences with a phenomenon or available metaphors were placed on the less-sophisticated end of the continuum, whereas the notions with abstract or molecular understandings were placed on the more-sophisticated end of the continuum-(Kim, 1989).

Developmental Patterns of Intuitive Ideas

The pattern of change of views across grade level is shown in Fig. 3. The abscissa of the diagram represents seven sub-concepts investigated : water vapor(WV) ; Humidity(H) ; evaporation(E) ; condensation(C) ; sublimation 1(S1) ; sublimation 2(S2) ; and dew point(DP). The ordinate of the diagram represents the continuum of sophistication. As the intuitive ideas move alogn the continuum, one may note the change from less sophisticated notions to those identified as being more sophisticated notions. Each circle in the figure represents a common intuitive idea identified. Lines with different thickness represents the developmental patterns of common intuitive ideas. The notions held by more than 30% of subjects in each grade level was selected and linked. Some sub-concepts have more than one common intuitive ideas held by more than 30% of subjects.

Some sub-concepts experienced changes across grade level while others did not(Fig. 3). Only one notion was predominant for two sub-concepts : sublimation 1 and 2. A gradual change of ideas across grade level was identified among five sub-concepts : water vapor, humidity, evaporation, condensation, and dew point.

Fifth-and eighth-graders' responses are mostly at the phenomenal or mechanical level with the exception of the sub-concept, water vapor or dew point. Eleventh-graders held views in transition. Some of the notions held by 11th-graders such as evaporation, condensation, sublimation 1 and 2 are at the phenomenal or mechanical level but others are at molecular level. Most of the college students' ideas were at the molecular level except for those of sublimation 1 and sublimation 2.



WV : water vapor ; H : humidity ; E : evaporation ; C : condensation ; S1 : sublimation 1 ; S2 : sublimation 2 ; DP : dew point

Fifth-graders — Eleventh-graders — Eighth-graders — College students

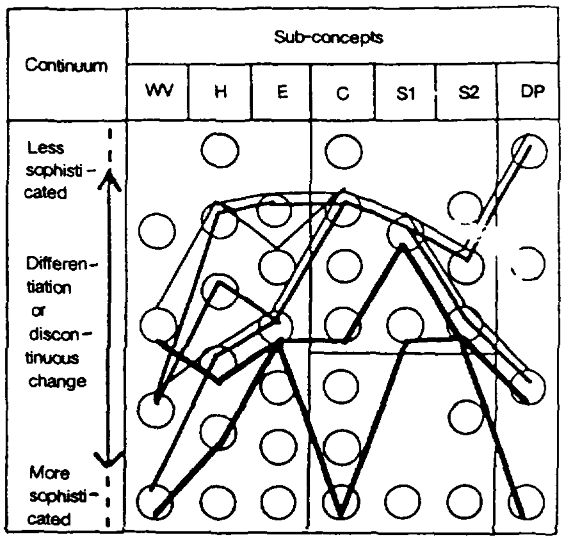
Fig. 3 Patterns of change across grade level

The Patterns of Change Across Ability level

Each grade level has three students categorized in the below average, average, or the above average ability. As stated earlier, fifth-, eighth-, and eleventh-graders were selected by the classroom teachers who already spent nearly one year with the students. College students were selected from three different groups but excluded because little information was available for their ability level.

The pattern of change of views across ability level is shown in Fig. 4. Some sub-concepts such as evaporation, and sublimation 1 and 2 experience little change across ability level, whereas sub-concepts such as water vapor, humidity, condensation, and dew point demonstrate some change across ability level.

Fig.4 indicates that the change of views across ability levels reveals similar trends to that of across grade levels. Evaporation, sublimation 1 and 2 notions indicated little change across the ability levels. The notions of water vapor, humidity, and dew point change gradually across the grade levels. Condensation notions change dramatically between average and high ability students. Notions of the low and average ability students show similar patterns. However, high ability students held quite different, and more sophisticated ideas than the low and average ability students.



WV : water vapor ; H : humidity ; E : evaporation ; C : condensation ; S1 : sublimation 1 ; S2 : sublimation 2 ; DP : dew point

Low ability — High ability — Average ability

Fig.4 Patterns of change across ability level

Conclusion and Discussion

The subjects investigated held various intuitive ideas about seven sub-concepts of water in the atmosphere. Some intuitive ideas about water in the atmosphere are similar to an Aristotelian view of water cycle. Ancient Greeks held a fairly accurate grasp of the water cycle: the ascent of water from the lakes, rivers, and oceans into the atmosphere, and its return again to the earth as precipitation. Form this investigation the subjects interviewed already held a firm understanding of the cyclic nature of water circulation. Several subjects attempted to explain evaporation and condensation using their prior knowledge of the water cycle. However, some of the subjects of the study, like the ancient Greeks, had difficulty in understanding the sub-processes of water cycle. For example, WV-Notion 1("evaporated water is air")is similar to the following Aristotelian view: "when the heat of the sun reached the earth's surface, it mixed with cold and moist water to form a new substance, warm and moist, essentially like air"(Frisinger, 1977). Another example comes from evaporation. Subjects rarely mentioned the rising mechanism of water while water evaporates; whereas most subjects believed that a certain falling mechanism existed for condensation. One possible explanation for those belief could be the dominance of an Aristotelian view of air or gas. Aristotle believed that air and fire possessed a lightness which tended to take them upwards to their proper places in the upper atmosphere(Frisinger, 1977; Mason, 1962). In this study, many subjects believed that evaporated water rose directly to the upper atmosphere forming clouds. Some subjects held more elaborated ideas: if there were clouds, the moisture in the air could not rise because the clouds blocked the way to rise, hence, the moisture remains in the air under the cloud causing high humidity.

Subjects often use metaphors(Muscari, 1988) to explain the sub-concepts of water in the atmosphere. Container concepts of evaporated water, rain or snow metaphor for condensation, and boiling process for evaporation are such examples. Two kinds of container concepts of evaporated water were found from this study: clouds and air. Lower graders tend to believe that evaporated water goes to the clouds, and dew is formed by the water coming down from the clouds. Clouds are bags of water(Bar, 1989) in the air. Many others believed that air could hold evaporated water. However, the fixed space(= volume) of the container(= air)prevents them from understanding the concept of relative humidity.

The intuitive ideas about condensation and sublimation 1 were categorized into two major groups: mechanical and molecular. The mechanical notions commonly includes falling down mechanisms: dew is formed by water falling down from the sky or clouds; and frost is formed by frozen water falling down from air or clouds. Obviously these notions were based upon the rain or snow metaphor.

There seems to be little differentiation between the concepts of evaporation and boiling. Few subjects perceived evaporation as a continuous process occurring day and night depending upon the relative humidity. Most of subjects responded that evaporation would be started when the heat or energy from the sun makes water molecules move faster. The exchange of water molecules across the boundary between the liquid and gas phase should be distinguished from the boiling of water, otherwise, the students may integrate the boiling mechanism within their notions about evaporation. For example, an eighth-grader believed that evaporation occurred if the temperature is above the boiling point, 100℃.

WV-Notion 3("water vapor is hydrogen and oxygen molecules") was held only by 11th-graders and college students who learned physical science or chemistry. This implies the influence of school learning on students' restructuring of intuitive ideas in an unanticipated way.

Finally, the phenomenal notions about sublimation 1 and 2 were more stable than any other intuitive ideas investigated. One reason for this belief may be due to their frequent experiences with water freezing or melting. Subjects seldom experience sublimation as an everyday process.

Students' ideas about some sub-concepts are restructured across grade and ability levels while those of others do not change. The notions of sublimation 1 and

2 are very stable, whereas those of water vapor, humidity, evaporation, condensation, and dew point show progression. Some sub-concepts are restructured earlier than others. Such sequence of restructuring of the sub-concepts was identified and named as "restructuring series": water vapor-humidity & dew point-condensation-evaporation-sublimation 1 and 2. Restructuring series suggest a psychological sequence of instruction, which implies: (a) a student has differential degree of understandings of the seven sub-concepts; (b) certain sub-concepts undergo restructuring earlier than other sub-concepts; and (c) certain sub-concepts which restructured earlier than others may serve as relevant anchoring ideas(Ausubel, 1968) for other sub-concepts.

Implications for Science Teaching and Suggestions for Further Research

The results of the present study show that learning science, earth science, or physical science did not make much of an impact on the cognitive structures of the students. This finding may suggest that educators have to change the science is taught. Science instruction should focus on the restructuring of students' established ideational systems and persuade or encourage students to replace their intuitive ideas.

The pre-service elementary teachers investigated in the present study held various intuitive ideas of water in the atmosphere. If a teacher holds intuitive ideas about the topic she or he is going to teach, students intuitive ideas might be reinforced or students may develop new intuitive ideas about the topic.

Textbooks are the most widely used learning material in science classrooms. The content and organization of the text should acknowledge and compensate for students' intuitive ideas. Some elements of the text may reinforce or initiate and develop students' intuitive ideas. Illustrations in the text frequently reinforce students' intuitive ideas. For example, the water cycle diagram in most textbooks reinforces the following intuitive ideas: (a) after evaporation water goes directly to the clouds; (b) evaporated water rises up in the sky and become clouds; (c) clouds are bags of water in the sky; and(d) dew comes down from the clouds. Many other illustrations in textbooks such as those found in describing photosynthesis and respiration may reinforce students' intuitive ideas, especially if the illustrations emphasize the mechanical aspects of the concept.

The sequence of ideas or the organization of content should be designed to improve instructional effectiveness. The psychological order as well as the structure of a domain should be considered in curriculum design. Some examples of psychological order refer to available relevant anchoring ideas or restructuring series of the concepts to be taught.

Some intuitive ideas are based upon metaphors. Such metaphors often behave as major obstacles in learning about science. for example, students have difficulty in understanding the concept of relative humidity because of the fixed volume of the container, air. These obstacles should be identified and the text is designed specifically to overcome these major obstacles.

The major role of evaluation is to measure students' achievement of learning objectives. The prevalence of students' intuitive ideas about science topics suggests the shift of focus of evaluation from the measure of attainment to the changes in views. Evaluation which focuses on changes in views may also drives students to change their intuitive ideas. Therefore, evaluation should explicitly reflect how to measure cognitive restructruing of the students. Research on intuitive ideas may provide guidelines or examples for such new evaluation. For example, the questions or tasks asked during clinical interviews could be exemplar evaluation items because such tasks or questions were specifically designed to probe cognitive structures among the subjects.

Suggestions for Further Research

The present study investigated students' intuitive ideas of water in the atmosphere in a Western culture. These investigations should be extended to other cultures. Such studies may provide insight about the role of culture and language to the construction of intuitive ideas.

These investigations should be extended to other unexplored science concepts. Such studies may find many additional intuitive ideas, their characteristics, and the patterns of change, which in turn provide much insight in understanding the intuitive ideas.

The classroom teachers' intuitive ideas about science topics and their influence on students learning science should be investigated.

Much research is also needed for the description of intuitive ideas. Intuitive ideas show variations in their content, stability, and contexts. Different type of intuitive ideas may require different instructional strategies to change. However, few classification scheme has been available.

Based upon the results of the present study, a written-test should be developed, and it can be used by classroom teachers or researchers to identify students' intuitive ideas prior to or after science instruction.

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요 약

미국 5-, 8-, 11-학년 및 대학교 학생들의 대기 중의 물 개념에 대한 직관적 해결

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(서울대학교)

이 연구의 목적은 (가)학생들의 "공기중의 물"에 대한 직관적 견해와 그 특성들을 파악하여 기술하고, (나) 나이와 학습 능력의 증가에 따른 직관적 견해의 분포 및 변화 경향의 파악 및 기술(description)에 있다.

미국 텍사스주 중부에서 36명의 연구대상 학생들이 선발되었다(5-, 8-, 11-학년 및 대학교 학생 각각 9명씩). 대학생들을 제외한 각 학년은 3명 씩의 우수, 보통 및 열등 학생들로 구성되었다. 연구 방법은 현상에 대한 면담법(Interview-About-Phenomena)이 사용되었다. 대기 중의 물은 7개의 종속개념(수증기, 습도, 증발, 응결, 승화Ⅰ과 Ⅱ, 그리고 이슬점)으로 세분되어 조사되었다.

연구 결과 각 종속개념마다 3개에서 7개까지 여러 직관적 견해들이 파악되었다. 학년과 학습능력이 증가 할수록 학생들은 더 정교한 직관적 견해를 보유하고 있었다. 파악된 직관적 견해들의 재구성(restructuring) 또는 보다 정교한(more sophisticated) 견해로의 변화는 종속개념에 따라 다르다. 직관적 견해들이 재구성되기 쉬움에 따라 종속개념들을 배열한 것을 "재구성 계열"(Restructuring series)이라 정의 하였으며 이는 다음과 같다. 수증기－습도－이슬점－응결－증발－승화Ⅰ과 Ⅱ.

이 연구의 결과는 과학교수 전략 및 과학 학습교재의 고안과 개발, 과학교사 양성과정, 그리고 과학학습 평가 등에 활용되어져야 할 것이다.