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Children's Conceptual Development: A Long-Run Investigation

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Abstract

The study sought to investigate conceptual change process. It is specifically aimed to probe children's initial ideas and how or to what way those ideas alter in the long run. A total of 18 children volunteered and participated in the study. Individual interviews were conducted. The children were asked to define the concept of evaporation, explain how this phenomenon occurs, and picturize this natural occurrence. A total of five consecutive interviews were conducted. All interviews were recorded and later transcribed. The results indicated the children's initial ideas got enriched in time. In this course of enrichment, instead of replacing radically their former conception with the novel one, the children seemed to have reinterpreted the new idea within the framework of their prior knowledge. The novel conception further is mixed up with the elements from both old and new beliefs leading intermediate structures to emerge. The data further indicated the children seemed to have been unable to recognize the discrepancies between their personal knowledge system to that of the scientific. They seemed lacking meta-conceptual awareness preventing them to compare and contrast their personal views to that of scientifically accepted one.

Key words: Conceptual change, Radical change, Enrichment process, Children conception

Introduction

Investigating how children's conceptual change or development occurs has been and is still one of the topics of concern in education. There is a good reason for this concern. Figuring out and knowing what initiates conceptual change, how it occurs, and what is the end product of it make us get a better understanding of this process and be aware of the limitations and allowances of our instructional strategies. In the literature, how one's conceptual change occurs is mostly affected by the ideas of Jean Piaget (1977). To him, as interacting with his/her surrounding, one either assimilates it or accommodates a novel mental structure in order to get adapted to it. According to this latter view, one, therefore, needs to construct a mental structure in order to perceive or cope with novel situations. This course of constructing action was seen as a radical or revolutionary change (Stafylidou & Vosniadou, 2004; Vosniadou, 1994; Vosniadou, Ionnides, Dimitrakopoulou Papademetriou, 2001), hard core change (Lakatos, 1970), or strong restructuring (Carey, 1985). To illustrate, abandoning the idea that the earth is a flat object with no motion and supported by ground or water and adopting the idea that the earth is a sphere object rotating around its axis and moving with no support (Vosniadou & Brewer, 1992) is viewed as a radical change. The important question that we ask to ourselves is now whether this sort of change could possibly happen, how it could be searched out and what others have done so far.

A number of empirical studies (Samarapungavan, Vosniadou, & Brewer, 1996; Samarapungavan & Wiers, 1997; Stafylidou & Vosniadou, 2004; Vosniadou & Brewer, 1992; Vosniadou, Skopeliti, Ikospentaki, 2004) investigated knowledge acquisition process or conceptual change through probing children's thoughts on astronomy, origin of species, fractions, shape of the earth, and day/night cycle respectively. In gathering data, these studies utilized an identical method. They probed the children's beliefs once through interviews or questionnaire and the development of children's understanding was determined by comparing beliefs held by different age groups. This comparison allowed the researchers to appreciate how children's conception alters from one grade to another. In other studies (Alvermann & Hague, 1989; Beerenwinkel, Parchmann, & Gr¨asel, 2011; Mikkilä-Erdmann, 2001), in an experimental (pre- and post-test) condition, the impact of a variable (refutation text or conceptual change text) on improving children's understanding was investigated. These studies indicated that the text involving or discussing alternative ideas is effective in initiating conceptual change process. However, none provided a qualitative analysis and seemed being short in offering a comprehensive account for the change process.

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The present study, unlike others cited above, aimed to investigate the change process through a different method. Rather than examining the ideas of different age groups or employing quantitative methods in gathering data, a qualitative and prolonged method was preferred to monitor the change process. In other words, in this paper, the change process is probed through a long-term follow-up. The questions such as 'What is the make-up of the initial idea?' 'What happens to it after an intervention?' And 'what happens to it in the long run?' became the focus of our concern.

The Aim of the Study

The aim of the present paper is to explore the development of children conceptual understanding for the concept of evaporation. It is specifically aimed to probe children's initial ideas on the concept of evaporation, how those ideas evolve when they get exposed by a scientifically accepted view, and what happens, in this transition, to alternative ideas. Therefore, the following research questions are the focus of our concern.

1. How do children's initial ideas about evaporation evolve?
2. What happens to alternative ideas if instruction solely focuses on the concept of evaporation?

Theoretical Framework

In order to comprehend how the learner grasps, modifies or shifts novel ideas, we primarily need to identify the notion of theoretical knowledge. According to Davydov (1990), theoretical and empirical thoughts possess discrete contents. Theoretical thought involves a system of interaction, an organized whole, which is the realm of objectively interconnected phenomena. This interconnection or essential relationship cannot be observed readily through the senses and it brings together things that are dissimilar, different, multifaceted, and not coincident. In contrast to empirical thought, a theoretical one does not find identical in every particular object in a class. Rather, it traces the interconnection of particular objects within the whole. To illustrate, recognizing the interconnection amongst sunrise, day, sunset, night, the Sun and the Earth's shape and rotation around its axis points to a theoretical understanding explaining the cycle of day and night. This notion, which is not readily observable, brings together the things (sunrise, day, sunset, night, the Sun, the Earth's shape, rotation around its axis) that are indeed dissimilar, different, multifaceted, and not coincident. How does such a theory grow in one's mind? Or How does one grasp a theoretical idea?

As studying semiotics, specifically language and interpreting the ideas of Ferdinand de Saussure, a linguist and semiotician, Chandler (2007) alleged that meaning is a structural and relational entity rather than a referential one. To him, within the system of the language, no sign makes sense on its own, but it gets meaning only in relation to other signs. In other words, the value of a sign depends on its relations with other signs within the system as a whole. Meaning of a sign hence refers to a specific position within a particular system and represents dissimilarities. It involves negative oppositional differences amongst signs. The growth of a sign therefore depends on other signs within a whole. Similarly, according to Davydov (1990), in the growth of theoretical ideas, the former idea is replaced by its own other retaining everything positive in it. In other words, because the conceptual growth happens through the differentiation of former ideas, new ideas exist with its relation to the former ones. For instance, after learning to draw the letter a , a child builds a mental structure for it. Thereafter, as learning to draw the letter g , the child might think, 'In order to draw the letter g, I just need to draw the letter a and add a tale to it'. The value of drawing the letter g therefore depends on its relation with another sign, the letter a, within the system of handwritten alphabet as a whole. Meaning of building the letter g hence refers to a particular position within the alphabetic system and represents the dissimilarity (the short tale in this specific case) from the letter a. The novel conception for the letter g hence depends on and grow from the differentiation of the former concept of a. The value of drawing the letter g could only exist with its relation to the letter a.

Further to that, similarly, to van Oers (2001), an abstract is not a recognition of a general characteristic of objects; rather, it is an attribute added to the objects in our thinking. In abstraction (in the growth of a theoretical idea), there is a process of enrichment rather than that of impoverishment. For instance, a child might initially think that every living that flies is a bird. The concept of bird thus brings together things (pigeons, crows, eagles, sparrows, flies, grasshoppers, bees, and the like) that are dissimilar, different, multifaceted, and not coincident. The flying property is therefore a dissimilarity of the concept of bird from the related concept of land animal. However, he/she later learns that the small featherless ones are indeed insects. Meaning of ‘bird’ within the system of signs for flying livings is differentiated once more and now represents both flying and feathered ones, which are two negative oppositional differences from the signs for the land animals and insects respectively. In other words, the feathered property is added to the meaning of the bird. This act of addition is therefore an enrichment process. The concept of bird is enriched by differentiating it from the insects and land animals.

Method

The Sample and the Study Context

The study was carried out at a rural elementary school located in Gaziantep, Turkey. A total of six third graders, of whom one was female and five were male, and twelve fourth graders, of whom nine were female and three were male volunteered and participated in the study. The concept of evaporation was first introduced to children at third grade under the unit of water cycle and, in order to reveal the children's initial ideas on evaporation, individual interviews were conducted. In the interviews, the children were particularly asked to define the concept of evaporation and explain how this phenomenon occurs. They were next asked to picturize this occurrence. They were further asked to describe and interpret their drawings. In this way, it is aimed to get a comprehensive view on their initial understanding of evaporation. All the interviews were video taped and carried out by the second author. Each interview lasted about 10-15 minutes. After these initial interviews, the second author met the children in their spare time at the school and had an instructional discussion on evaporation.

The discussion started with having a conversation on the meaning of the concept of evaporation. One child pointed that evaporation occurs when the water boils in a kettle. Another one stated that if there is water in a lake, when the Sun touches it, it evaporates. Still another stated if we pour some cologne on to our hands, it evaporates. The teacher repeated the child's explanation and also told that when we pour cologne on our hands, it takes heat from us as it evaporates. A different child restated the teacher's utterance. Another one stated that because of the Sun, water in pools runs out in time. The discussion next continued with an experiment where one child, in front of the class, dipped a piece of wipe in a glass of water and wiped his face with it. The child was afterward asked what she might have felt. After she said she had felt cool, the teacher asked the class to offer an explanation for why she has felt that way. The children provided various explanations. For instance, one child stated, 'when cold water touches our face, it takes its temperature; it cools our face. Another child stated, 'because water is cold, she felt cool', and another one stated, 'her face was initially hot. Later, when she wet her face, the water evaporated and water is formed, because of that, she felt cold'. The dialogue continued with a discussion. They discussed what happens if hot water was used instead and why one feels cool after having a shower. Then, the teacher showed a photo of a lake taken in winter, in which there is thick fog formed on its surface and asked the children what they see in the photo. The children jointly indicated that there is evaporation on the surface of the lake. They further indicated that heat or temperature is responsible for this occurrence and the source of heat ought to be the Sun. The dialogue later continued with a discussion on whether evaporation causes a decrease or no change in the amount of water in the lake. Then, the teacher showed a picture very similar to the one (Figure 1) depicted below.

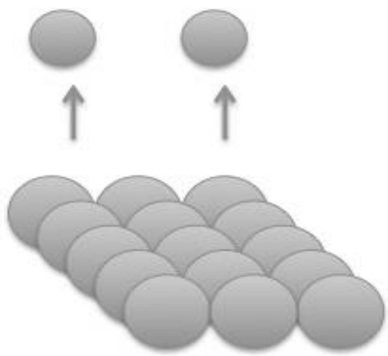


Figure 1. The water particles leaving the surface layer

The teacher thereafter provided an explanation for evaporation process and pointed to such details: (1) in water are tiny particles (pointing to Figure 1), (2) these tiny particles could not be seen by naked eye, (3) the particles tightly hold one another from below and sides, (4) when the particles get heat, they start to move and begin to move farther away form each other, (5) particles with high energy get their energy from other particles, (6) particles possessing higher energy get into the space above the liquid, (7) the remaining particles have a lower energy, and (8) evaporation is hence a cooling process. The teacher did this explanation two times. Thereafter, the children played a game. The teacher first drew a big circle in front of the class and asked for volunteers. Six children volunteered and got into the circle. Then, the teacher asked them to imagine themselves as being water particles in a cup. The children standing up then started to move in their place. After the teacher said that they are getting heat energy, the children began to move faster and bump into one another. The bumping eventually resulted in two children jumping out of the circle. The remaining ones however sustained their motion. Right after, the teacher intervened the play and stated that there happened an energy transfer and the particles with higher energy got out of the liquid. This is called evaporation. The teacher therefore fulfilled the activity with an emphasis on evaporation process without mentioning or discussing any alternative conceptions that children had or could possibly hold. Afterward, individual interviews were again conducted with the children. In the mean time, no child had further instruction on evaporation. The first interview was conducted right after the above discussion on the same day, the second one is done one week later, the third one was done two weeks later and, the fourth one was done nine months later. Together with the interview done at the beginning of the study, a total of five interviews were conducted with each pupil. All the interviews were recorded and, consequently, a total of 90 videos were taped.

Data Analysis

The videotapes were first transcribed. The transcriptions were next read several times and inductively analyzed (Patton, 2001). In this course of analysis, numerous patterns (codes) were discovered and the emerging codes were later defined. Operational definitions for the codes are depicted in Table 1

Table 1. Operational definitions for emergent codes

Codes	Definitions	Exemplary Children's Explanations
1. Cycle	The statements that indicate that the formation of snow, cloud or rain is part of evaporation process; or drawing a cloud(s) without declaring it in the interview.	*When we put the fire under water, it evaporates. Water then rises into the air. Then it becomes cloud.*
2. Particle	The statements that indicate evaporation happen as tiny particles (micro particles that could not be seen by naked eye) of water get into air or drawing small circles as a representation of water particles without declaring them in the interview.	*For instance, if we put some water in a glass. There are small particles that we could not see. Under the Sun, those particles fly into air.*
3. Boiling	The statements that indicate evaporation happen as a result of boiling or cooking of water in a pot.	*If you put some water in a pot, it evaporates by boiling.*
4. Melting	The statements that indicate evaporation happen as a result of melting of water.	*Put some water in a deep cup. If you put it under the Sun, it melts, evaporates.*
5. Warmth	The statements that indicate temperature, energy, the Sun, or heat causes evaporation to begin or drawing the picture of the Sun without declaring it in the interview.	*Let's say there is water. We put it under the Sun. As the Sun delivers its heat to it, it evaporates.*
6. Smoke	The statements that indicate evaporation happen as a result of burning something.	*Like this, you will burn bushes, smoke occurs.*
7. Fog	The statements that indicate evaporation happen as a result of formation of fog on the window.	*When you look at the window, if evaporates, you could not see outside. This happens when inside is hot.*

Based on operational definitions in Table 1, the video-transcripts were coded. Two additional coders also used the table and coded randomly selected transcriptions independently. Over ninety percent of the codes showed consistency, which indicated strong inter-coder reliability (Miles & Huberman, 1994).

The Results

Based on the operational definitions displayed in Table 1, the children's utterances were then analyzed. For instance, the following explanations are taken from the interviews with Pupil 16. In the interviews, she is repeatedly asked to explain evaporation process. She is also asked to draw a picture of the process and describe it in detail. Below are her explanations, drawings and descriptions of her drawings.

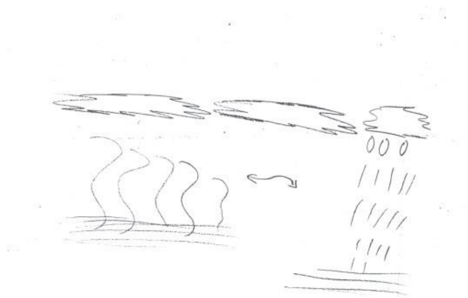
An Example

Former Interview

Pupil's (Pupil 16) Explanation:

In this process, the vapor moves from sea to clouds and moves from clouds to sea too. In the clouds, it turns into rain and falls into sea.

Pupil's Drawing and Description:

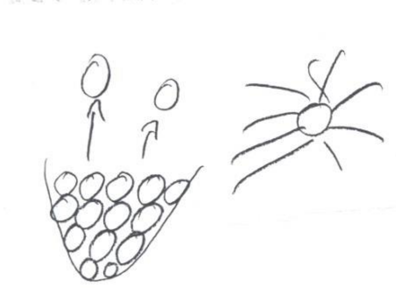


This is the sea. It is evaporating and going to the clouds. It is coming back from the cloud as rain.

First Interview

Pupil's Explanation:

It evaporates as delivering heat. The buds (particles) in the water jump into air when they get heat. They are attached to one another. When they get heat, they get separated from each other. Some that take a lot of energy jump up.



The heat from the Sun reaches to the buds. The buds that have high energy jump into air.

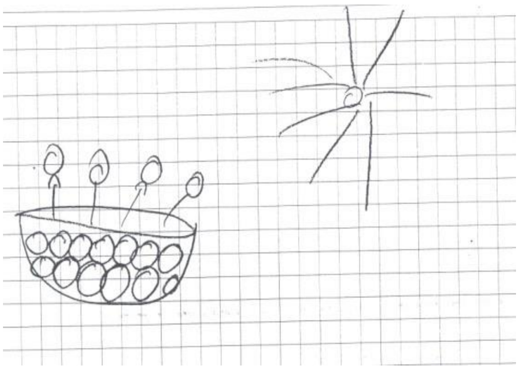
Pupil's Drawing and Description:

Second Interview

Pupil's Explanation:

There are buds in the cup. After they get heat, since they are attached, they get separated. Those they get more energy from the others jump into air. As heat reaches, water evaporates.

Pupil's Drawing and Description:



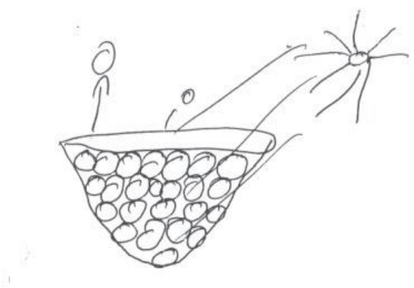
The Sun offers its heat, the buds that gets high energy separate from one another, some taken high energy jump up.

Third Interview

Pupil's Explanation:

Some water in a glass and there are buds in it that we could not see. When the Sun touches that water, the buds get separated from one another. Those getting a lot of energy jump into air.

Pupil's Drawing and Description:



As the Sun touches the water in the cup, the buds get separated from one another and those getting a lot of energy jumps into air.

Fourth Interview

Pupil's Explanation:

For instance, there is a lake, when the Sun gives heat to it, it goes to clouds. The clouds could not hold it and falls back to the earth as rain. Somewhere, there is a lake or sea. As the Sun gives heat, it evaporates and the clouds, in time, could not hold it. It comes down to the earth as rain.

Pupil's Drawing and Description:

In the former interview, she associated the evaporation process with the formation of cloud and rain. She, later, in the first, second and third interviews, associated evaporation process with small unobservable particles moving and escaping into air. She also pinpointed the important role of heat in this course. In the last interview, however, she again associated it with the formation of clouds and rain, and highlighted the role of the Sun as a heat source. In our analysis, her accounts are compared to the operational definitions depicted in Table 1 and assigned to such codes as Cycle, Particle-Warmth, Particle-Warmth, Particle-Warmth and Cycle-Warmth respectively. In a similar fashion, the remaining children's accounts are analyzed. Table 2 displays the emergent codes.

Here is a lake. Here as the Sun gives its heat, this water evaporates and goes to the clouds. Below, the clouds, in time, could not hold it, it comes down to the lake as rain.

Analysis of Children's Accounts for the Concept of Evaporation

In order to compare and see the trends in children's accounts depicted in Table 2, five figures were created. The figures allowed us to reduce and visualize data and, therefore, to perceive likely pattern(s) in the codes. Figure 2 depicts the initial codes emerging from the former interviews. In the following and subsequent figures, the capital letter C stands for Cycle, the letter B for Boiling, W for Warmth, P for Particle, F for Fog, S for Smoke and the letter M stands for Melting. To illustrate, the letters C-B-W signify the codes of Cycle, Boiling, and Warmth respectively.

Table 2. Analysis of children's accounts for the concept of evaporation

Children	Former Interview *(Before Intervention)*	First Interview *(After Intervention)*	Second Interview *(One week later)*	Third Interview *(Two weeks later)*	Fourth Interview *(Nine months later)*
	Codes				
Pupil 1 *(Male, third grade)*	Cycle Warmth	Cycle Particle Warmth	Particle Warmth	Cycle Particle Warmth	Cycle Particle Boiling Warmth
Pupil 2 *(Male, third grade)*	Smoke	Cycle	Melting Particle Warmth	Cycle Particle Boiling	Cycle Particle Boiling Warmth

Pupil 3 *(Male, third grade)*	Cycle Warmth	Cycle Particle Warmth	Particle Warmth	Particle Warmth	Cycle Particle Warmth
Pupil 4 *(Male, third grade)*	Cycle Warmth	Cycle Particle Warmth	Cycle Particle Warmth	Cycle Particle Warmth	Cycle Particle Warmth
Pupil 5 *(Male, third grade)*	Cycle Warmth	Cycle Particle Warmth	Particle Warmth	Particle Warmth	Cycle Particle Warmth
Pupil 6 *(Female, third grade)*	Boiling Warmth	Boiling Warmth	Particle Boiling Warmth	Melting Particle Warmth	Melting Particle Warmth
Pupil 7 *(Male, fourth grade)*	Fog	Boiling Warmth	Particle Warmth	Particle Warmth	Cycle Warmth
Pupil 8 *(Female, fourth grade)*	Boiling Warmth	Particle Boiling Warmth	Particle Boiling Warmth	Warmth	Cycle Boiling Warmth
Pupil 9 *(Female, fourth grade)*	Boiling Warmth	Particle Warmth	Particle Warmth	Particle Warmth	Warmth
Pupil 10 *(Female, fourth grade)*	Cycle Warmth	Cycle Particle Warmth	Particle Warmth	Particle Warmth	Cycle Particle Warmth
Pupil 11 *(Female, fourth grade)*	Melting Warmth	Particle Warmth	Particle Warmth	Particle Warmth	Cycle Boiling Warmth
Pupil 12 *(Male, fourth grade)*	Warmth	Boiling Warmth	Particle Warmth	Warmth	Cycle Particle Boiling Warmth
Pupil 13 *(Female, fourth grade)*	Cycle Boiling Warmth	Particle Warmth	Particle Warmth	Particle Warmth	Cycle Particle Warmth
Pupil 14 *(Male, fourth grade)*	Cycle Warmth	Particle Warmth	Particle Warmth	Particle Warmth	Cycle Warmth
Pupil 15 *(Female, fourth grade)*	Boiling Warmth	Particle Warmth	Particle Warmth	Particle Warmth	Particle Boiling Warmth
Pupil 16 *(Female, fourth grade)*	Cycle	Particle Warmth	Particle Warmth	Particle Warmth	Cycle Warmth
Pupil 17 *(Female, fourth grade)*	Cycle Warmth	Particle Warmth	Particle Warmth	Particle Warmth	Cycle Particle Boiling Warmth
Pupil 18 *(Female, fourth grade)*	Boiling Warmth	Particle Warmth	Particle Warmth	Particle Warmth	Particle Boiling Warmth

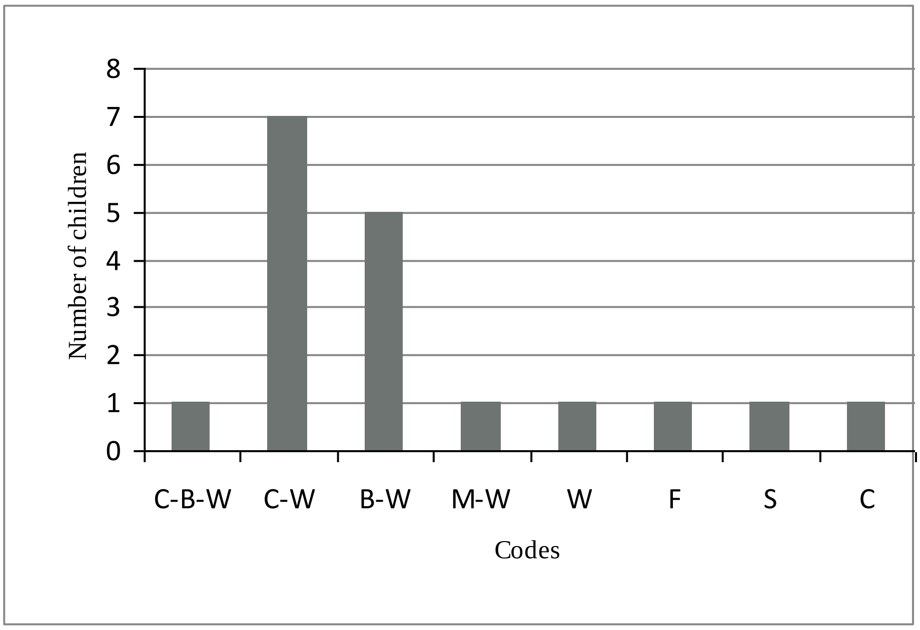


Figure 2. The codes emerging from the former interview

Figure 2 indicates that a total of seven children associated evaporation with the concept of Cycle and Warmth and generally stated that the Sun heats up the water causing water to evaporate and going to the cloud that eventually results in the formation of rain. Five children, associated it with the concept of Boiling and Warmth. They generally claimed that evaporation occurs as a result of boiling of the heated water. One child associated it with the concepts of Cycle, Boiling and Warmth, another one associated with Warmth, another one with Fog, another with Smoke and still another associated with Cycle. A total of nine children associated evaporation with cycling and fourteen children associated it with heating. The former interview further indicated that no child mentioned the particle nature of evaporation process. Moreover, the children's accounts fell into 8 different codes (CBW, CW, BW, MW, Warmth, Fog, Smoke, and Cycle). One code (CBW) involved three concepts (Cycle, Boiling and Warmth), three codes (CW, BW and MW) involved two concepts and four codes involved only one concept.

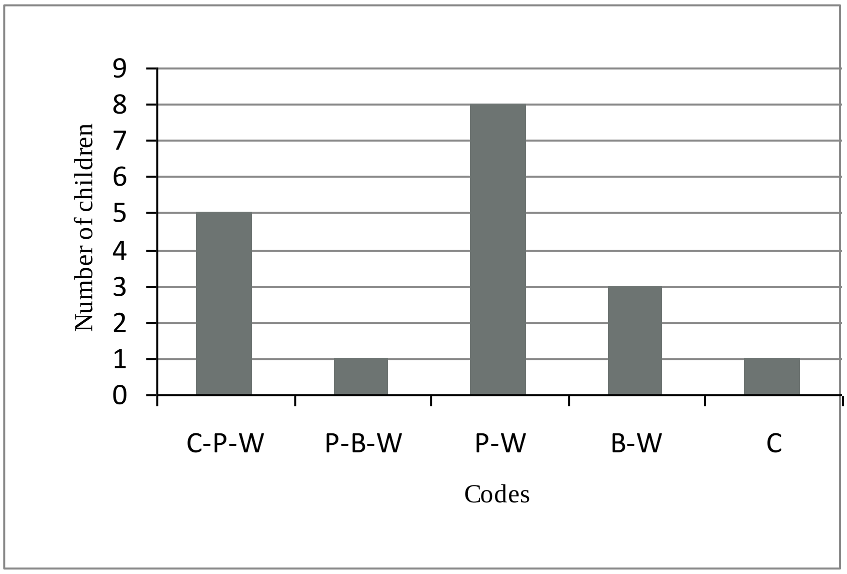


Figure 3. The codes emerging from the first interview

The first interview (Figure 3) indicates that eight children associated evaporation with the concept of Particle and Warmth and generally stated water consists of small unobservable particles and when they get heated, some of them with high energy escape into air. Five children associated it with the concept of Cycle, Particle, and

Warmth. One child associated it with the concepts of Particle, Boiling, and Warmth, and another one associated it with Cycle. The interview further indicated that 14 children were able to associate evaporation process with particle motion. Moreover, the children's accounts fell into 5 different codes. A total of six codes involved three concepts, eleven codes involved two concepts and one code involved only one concept.

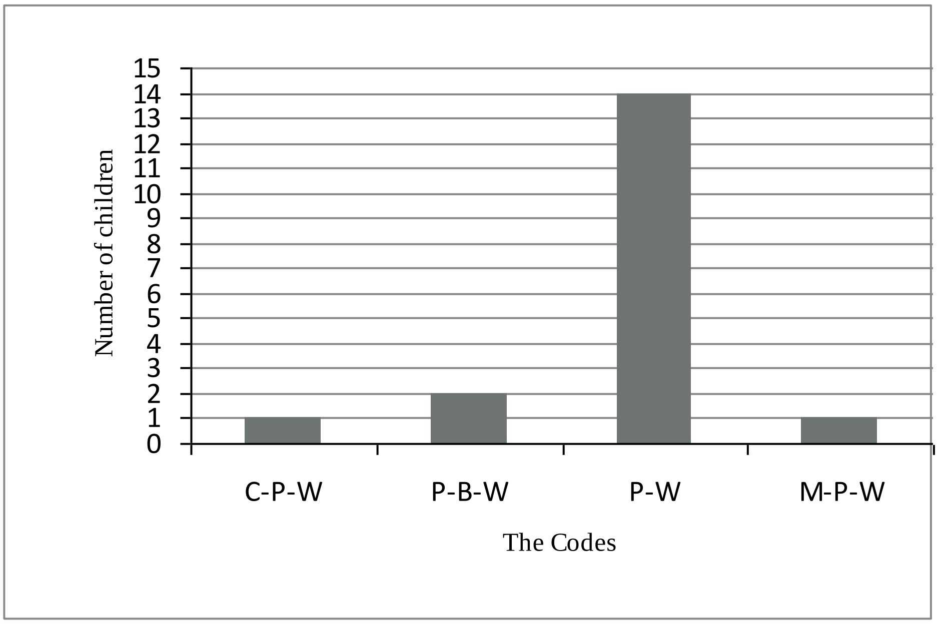


Figure 4. The codes emerging from the second interview

The second interview (Figure 4) indicates that all the children successfully demonstrated particle motion view of evaporation process. Fourteen children associated it merely with Particle and Warmth. Two children associated it with the concepts of Particle, Boiling and Warmth. One child associated it with the concepts of Cycle, Particle, and Warmth, and another one associated it with Melting, Particle and Warmth. The second interview further indicated that all the children (18 children) were able to associate evaporation process with particle motion. Moreover, the children' accounts fell into 4 different codes. A total of four codes involved two concepts, fourteen codes involved two concepts and no code involved one concept.

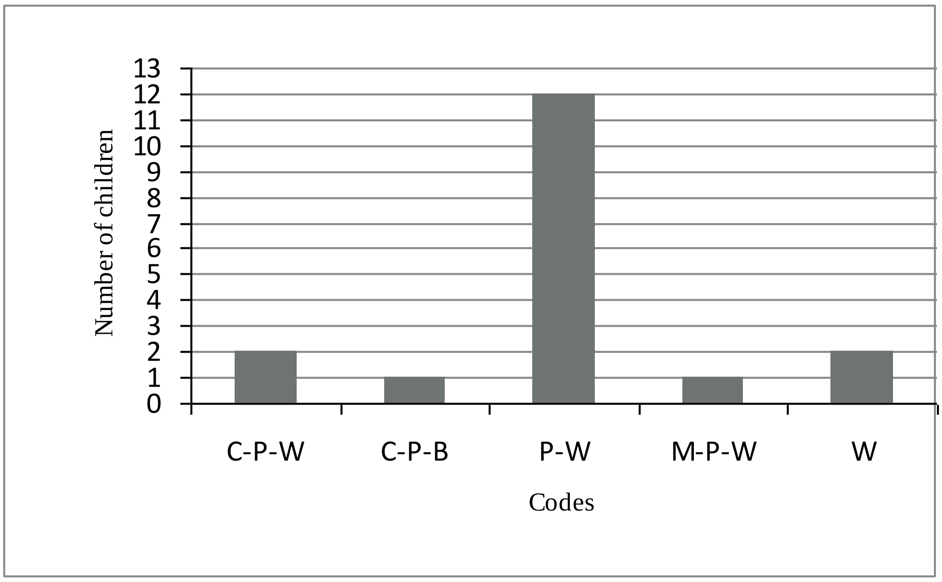


Figure 5. The codes emerging from the third interview

The third interview (Figure 5) indicates that 12 children associated evaporation with the concepts of Particle and Warmth. Two children associated it with the concepts of Cycle, Particle, and Warmth and another two associated with Warmth. One child associated it with the concepts of Cycle, Particle, and Boiling, and another one associated it with Melting, Particle and Warmth. The third interview further indicated that a total of 16 children were able to associate evaporation process with particle motion. Moreover, the accounts fell into 5 different codes. A total of four codes involved three concepts, twelve codes involved two concepts and two codes involved only one concept.

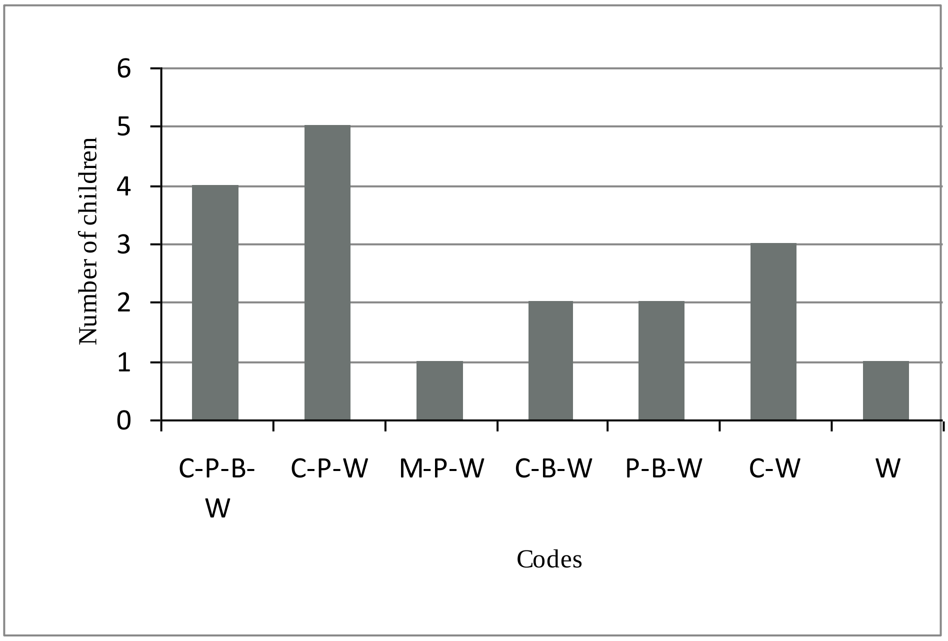


Figure 6. The codes emerging from the fourth interview

The fourth interview (Figure 6) indicates that four children associated evaporation with the concepts of Cycle, Particle, Boiling and Warmth. Five children associated it with the concepts of Cycle, Particle, and Warmth. Three children associated evaporation with the concepts of Cycle and Warmth. Two associated it with Cycle, Boiling and Warmth and another two associated with Particle, Boiling and Warmth. One child associated it with the concepts of Melting, Particle, and Warmth and another one associated it with solely Warmth. The final interview further indicated that 12 children were able to associate evaporation process with particle motion. However, this association not only involved particle motion but also included other notions such as Cycle, Boiling and Melting. Moreover, the children's accounts fell into 7 different codes. A total of four codes involved four concepts, ten codes involved three concepts, three codes involved two concepts and one code involved only one concept.

The Quality of Children's Explanations Uttered in the Last Interview

In order to examine the quality of children's explanations, their (Pupil 1, 2, 3, 4, 5, 6, 10, 12, 13, 15, 17, and 18) utterances indicating particle understandings in the fourth interview were singled out. Table 3 depicts those utterances taken from the last interview. Comparing the children's accounts to those having emerged from the discussion, a number of differences were observed. First of all, the children used some terms that were indeed not pointed out in the teaching discussion. The words such as jammed, small balloons (P1), blow up (P2, 5), buds (P4, 15, 18), move up and down (P6), bubbles (P10), and rolling over (P12) that have not been brought out by the teacher. Second, even though the teacher provided a detailed explanation (causatively linked statements in the form of a complete story regarding the process of evaporation), no child was able to do so. Their explanations involved missing parts or inappropriate links. To illustrate, Pupil 3 invoked that when the Sun gives heat, when they get heat, they jump into air. This explanation excluded the vital connection between heat and motion. The student seemed to have failed in establishing the linkage between heat provided by the Sun and the kinetic energy of the particles. Finally, their (P1, 2, 4, 5, 6, 10, 12, 15, 17, and 18) explanations were mostly off base or inaccurate indicating important deviations or divergence from the scientific meaning for the concept of evaporation. The Pupil 2, for instance, stated that there are small particles in water. When they blow up, some are very close to one another, when they blow up, they evaporate. The child seemed to believe that the water particles blow up in order to evaporate.

Table 3. Children's utterances on the concept of particle motion

Children	The Children's Explanations Fourth Interviews *(Nine months later)*
Pupil 1 *(Male, third grade)*	...When it provides heat, water gets heat, heat gives itself over and jump into air. It squeezes itself. They get ***jammed***. They jump into air. There are ***small balloons*** that we could not see. They evaporate fast into air. Being in gas form like steam they go into air...
Pupil 2 *(Male, third grade)*	...There are small particles in water. When they ***blow up***, some are very close to one another, when they blow up, they evaporate...
Pupil 3 *(Male, third grade)*	...There are small particles that we could not see. When the Sun gives heat, when they get heat, they jump into air...
Pupil 4 *(Male, third grade)*	...In water are tiny tiny particles. They are connected. They never get detached. When the heat from the Sun touches them, those having large amount of heat get into air. The remaining ones take heat from those to the right and left. When some water is put into a kettle and when we put it on a heater or something else, when it gets hot, ***buds*** get formed and water begins to splash. Evaporation, there is smoke rising from under the kettle. Those are evaporation...
Pupil 5 *(Male, third grade)*	... The water becomes hotter and hotter and is, in time, becoming lesser and lesser in amount. Since it evaporates, small things get formed. The molecules are formed and later when it ***blows up***, when they stick together, they do not blow up, they hold each other tightly. When they get separated, they turn into rain in the air...
Pupil 6 *(Female, third grade)*	...There was a lake and there was small particles in it. Those particles melted and ***moved up and down*** and there happened evaporation...
Pupil 10 *(Female, fourth grade)*	...There are combined ***bubbles*** in the water. Every time when the heat of the Sun touches, they get detached and rise, evaporate...
Pupil 12 *(Male, fourth grade)*	...There is a cup and water in it on a heater. The water boils, then it goes up by ***rolling over.*** The rounds mean that it is boiled...
Pupil 13 *(Female, fourth grade)*	...Initially, the liquids take heat. Then, because they get heat, the molecules on the surface, because they get more heat, they evaporate.
Pupil 15 *(Female, fourth grade)*	Let's assume we have boiling water in a kettle. Because the heater gives heat, it evaporates. The little little particles ***buds*** go into air. Because they could not hold each other, they go into air. Up on getting heat from the Sun, water evaporates. There is some boiling in water. Then, buds get formed. They go into air as steam...The heater gives heat to it and it turns into steam. The buds get larger and becomes steam.
Pupil 17 *(Female, fourth grade)*	...For example, in order to cook a meal, we put some water in a cup. When that cup becomes hot, molecules get formed on it. They indicate that the water is boiling. Then, when water boils well, steam gets formed over it and goes into air...
Pupil 18 *(Female, fourth grade)*	There is some water in a cup. Those particles, when they boil, evaporate. When the Sun gives heat to water, the water takes heat, there happens smoke going up, buds going up. In order for the Sun to touch the water, ***buds*** get formed. When the Sun gives its heat to the water, it rises to air.

Discussion and Conclusion

Children's Initial Ideas Enriched in Time

The children initially could not display a particle motion understanding of evaporation process and seemed to have a variety of alternative conceptions. First of all, some (Pupil 1, 3, 4, 5, 10, 13, 14, 16, and 17) viewed evaporation as the transition of water from liquid to gas and related it to the phenomenon of water cycle. They seemed to possess an alternative conception that formation of cloud, rain or snow is also part of evaporation. Some other (Pupil 6, 8, 9, 13, 15, and 18) seemed to believe that evaporation occurs as water boils. These children seemed to possess an alternative conception that evaporation starts when only water reaches at boiling temperature. One student further inaccurately viewed it as the formation of fog and another as the formation of smoke and still another as melting. Later, in the teaching discussion, the teacher pointed out that evaporation is the result of interplay between heat and water particles (without addressing those alternative ideas). The teacher stressed on the concept of evaporation and its meaning (particle, heat, and motion relationship). This notion, in the initial weeks (in the first, second and third interviews), was grasped by 8, 14 and 12 children respectively. A radical change in their thoughts seemed to have happened. However, nine months later, the children (Pupil 1, 2, 3, 4, 5, 6, 10, 12, 13, 15, 17, and 18) demonstrating particle motion understanding began to involve the elements from the concepts of Cycle, Boiling, or Melting in their elucidations. Former beliefs seemed not being lost and the particle motion property was added to those beliefs. Therefore, the concept of evaporation seemed to get enriched. This result indicated that, in conceptual development, rather than replacing the former idea with the novel one or completely abandoning the former one, the children differentiated their former beliefs. This finding corresponds to the claims that peripheral theory change (Chinn & Brewer, 1998) or evolutionary constant development (Saglam, 2010) happens in the course of conceptual change.

To illustrate, the Pupil 15 initially thought that evaporation occurs when water boils in a kettle upon exposed to heat. She hence seemed to have established a linkage amongst heat, boiling and the transition of water (from liquid to gas phase). The concept of evaporation thus brought together heat, boiling and the transition of water that are in fact dissimilar, different, multifaceted, and not coincident. She, later on (in the first, second and third interview), however began to think that this process occurs when small particles get into air. At this point, one could think that there is a replacement or radical change in her knowledge structures. Yet, she, in the final interview, started to believe again that in the course of evaporation, when water boils in a kettle, the water particles get into air. She seemed to have established a linkage amongst heat, boiling, particle motion, and transition of water. Her initial understanding of evaporation has not been therefore completely lost. The linkage amongst heat, boiling and the transition of water is not lost and the particle motion property is added to the meaning for evaporation. The concept of evaporation is thus enriched by adding particle motion understanding into the former explanatory framework.

Intermediate Structures Emerging

The final interview indicated that 12 children were able to associate evaporation process with particle motion. However, this association not only involved particle motion but also included former notions such as Cycle, Boiling and Melting. Further to that, the quality of the children's explanations indicated that the pupils carried forward their personal views. To illustrate, their utterances involved such terms as jammed, small balloons (P1), blow up (P2, 5), buds (P4, 15, 18), move up and down (P6), bubbles (P10), and rolling over (P12). This therefore seem to indicate that the novel structures did not surface or exist independent from the former beliefs. In other words, the novel ideas existed with its relation to the former ones. The explanations hence involved the elements from both the former and new beliefs leading unique intermediate structures to emerge. The children seemed modifying their initial structures to make them more consistent with the scientifically accepted one by gradually reinterpreting their presuppositions (Vosniadou & Brewer, 1992). In another saying, the children seemed trying to reconcile their prior conceptions with the scientific one (Stafylidou & Vosniadou, 2004). This intermediate structure is both mixed up with the elements of personal and those of scientific view. This finding corresponds to the claims that intermediate synthetic (Samarapungavan, Vosniadou, & Brewer, 1996; Vosniadou, 1994) or hybrid (Jung, 1993 as cited Duit & Treagust, 2003) structures emerge in children beliefs in the course of conceptual change.

Even though those structures were not fully accurate from a scientific viewpoint, the children used them in a consistent manner. This finding is, however, in conflict with the idea of ‘knowledge in pieces’ proposed by diSessa (1988). He claimed that intuitive physics is a fragmented collection of ideas that are loosely connected and reinforcing and have none of the commitment and systematicity that could be attributed to theories. Unlike this claim, the present data indicated inversely that the children's former ideas involved theory like beliefs. Theories are essential relationships that bring together things that are dissimilar, different, multifaceted, and not coincident (Davydov, 1990, p. 255). In the present study, the children established relationships, even not scientifically fully accurate, amongst water particles, warmth, and boiling, cycle, or melting. Those beliefs helped them explain observations they faced in every day life in the past, are still helpful in the present, and will continue being helpful in their future observations.

Some Alternative Ideas Disappearing but Some Retained

The results indicated that solely focusing on meaning of evaporation without probing and discussing the children's alternative conceptions is almost useless in getting rid of those alternative conceptions. The children's alternative ideas such as 'formation of cloud, rain or snow is also part of evaporation'(P1, 2, 3, 4, 5, 7, 8, 10, 11, 12, 13, 14, 16, and 17), 'evaporation starts when only water reaches at boiling temperature'(P1, 2, 8, 11, 12, 15, 17, and 18), and 'evaporation happens as a result of melting of water' (P6) were retained while others such as 'evaporation occurs as a result of formation of fog on a window' (P7) and 'evaporation occurs as a result of burning something' (P2) disappeared. The children seemed to have kept their former alternative ideas that they found related to the evaporation process, but abandoned those they believed irrelevant. They, unlike scientists, seemed not being fully aware of or lacking metacognitive awareness of their possession of alternative ideas. This finding corresponds to the claim put forward by Vosniadou and Ioannides (1998) that the children seem to be not aware of the explanatory frameworks they hold or have constructed. To them, this lack of metaconceptual awareness prevents children from questioning their prior knowledge structure and encourages the assimilation of new information into this existing structure. This assimilatory activity however seems to form the basis for the creation of synthetic models, misconceptions or inconsistencies in children's reasoning.

This finding hence supports the idea of the importance of making children aware of their implicit representations, beliefs, or presuppositions and of providing meaningful experiences in instructional activities to motivate children to understand the limitations of their explanations and be motivated to change them (*ibid.*). In order to do this, according to Vosniaedou and Ioannides (*ibid.*), it is necessary to create learning environments where children could freely express their thoughts, participate in discussions, verbally express their own ideas. This will eventually cause the internal ideas to surface, be discussed, and compared to those of others. This activity, even seems being time consuming, is important for children to get aware of their own alternative conceptions. In the present study, to illustrate, the alternative conception that *evaporation starts when only water reaches at boiling temperature* could be discussed in the class. Such steps could be taken as, discussing whether clothes could get dried or not on winter days; probing children's ideas and comparing and contrasting them to that of others; designing and conducting related experiments; investigating for instance what will happen if a wet towel is left in the classroom for one day; and evaluating and making comments on the result of this inquiry.

Concluding Remarks

In summary, the findings of the present study have not supported the radical change view. In other words, abandoning the old concept and adopting that of the novel unmistakably and independently from former beliefs did not happen in actuality. The children, rather than grasping all properties of evaporation process or building a perfect understanding as it is presented by the teacher, reinterpreted the novel information within the framework of their former knowledge system. That is, the novel conception for evaporation depended on and grew from the differentiation of the former conceptions. Moreover, the novel conception was both mixed up with the elements of personal and those of scientific view leading intermediate structures to emerge in children's mind. The data further indicated that the children seemed to have been unable to recognize the discrepancies between their personal knowledge system and that of the scientific. It could, therefore, be speculated that children lack meta-conceptual awareness preventing them to compare and contrast their personal view to that of scientifically accepted one.

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References

Alvermann, D. E. & Hague, S. A. (1989). Comprehension of counterintuitive science text: Effects of prior knowledge and text structure. *Journal of Educational Research, 82*(4), 197–202.

Beerenwinkel A., Parchmann I. and Gr¨asel C., (2011). Conceptual change texts in chemistry teaching: a study on the particle model of matter. *International Journal of Science and Mathematics Education, 9,* 1235–1259.

Carey, S. (1985). *Conceptual change in childhood*. Cambridge, MA: The MIT Press.

Chandler, D. (2007). *Semiotics: the basics.* New York, NY: Routledge.

Chinn, C. A. & Brewer, W. F. (1998). An empirical test of a taxonomy of responses to anomalous data in science. *Journal of Research in Science Teaching, 35*(6), 623–654.

Davydov, V. V. (1990). *Soviet studies in mathematics education: Vol. 2*. Types of generalization in instruction: Logical and psychological problems in the structuring of school curricula (J. Kilpatrick, Ed., & J. Teller, Trans.). Reston, VA: National Council of Teachers of Mathematics. (Original work published 1972)

diSessa, A. (1988). Knowledge in pieces. In G. Forman & P. Putall (Eds.), *Constructivism in the Computer Age* (pp. 49-70). Hillsdale, NJ: Lawrence Erlbaum Associates.

Duit, R. & Treagust, D. (2003). Conceptual change: a powerful framework for improving science teaching and learning. *International Journal of Science Education, 25* (6), 671-688.

Harrison A. G., & Treagust D. F. (2001). Conceptual change using multiple interpretive perspectives: two case studies in secondary school chemistry. *Instructional Science, 29,* 45–85.

Lakatos, I. (1970). Falsification and the methodology of scientific research programmes. In I. Lakatos & A. Musgrave, eds, *Criticism and the Growth of Knowledge.* Cambridge: Cambridge University Press.

Mikkilä-Erdmann, M. (2001). Improving conceptual change concerning photosynthesis through text design. *Learning and Instruction, 11*, 241–257.

Miles, M. B. & Huberman, A. M. (1994). *Qualitative data analysis.* Thousand Oaks, CA: Sage Publications.

Patton, M. Q. (2002). *Qualitative research & evaluation methods.* Thousand Oaks, CA: Sage Publications.

Piaget, J. (1977). *The development of thought: Equilibration of cognitive structures.* New York, NY: Viking Press.

Saglam, Y. (2010). Is conceptual growth an evolutionary development of a prime structure? a dialectic Davydovian approach, *Eurasia Journal of Mathematics, Science & Technology Education, 6*(2), 139-147.

Samarapungavan, A., Vosniadou, S., & Brewer, W. F. (1996). Mental models of the earth, sun, and moon: Indian children's cosmologies. *Cognitive Development, 11*, 491–521.

Samarapungavan, A. & Wiers, R. W. (1997). Children's thoughts on the origin of the species: A study of explanatory coherence. *Cognitive Science, 21*(2), 147-177.

Stafylidou, S. and Vosniadou, S., (2004), The development of students' understanding of the numerical value of fractions, *Learning and Instruction, 14,* 503-518.

van Oers, B. (2001). Contextualisation for abstraction. *Cognitive Science Quarterly, 1*, 279-305.

Vosniadou, S. (1994). Capturing and modelling the process of conceptual change. *Learning and Instruction 4,* 45-69.

Vosniadou, S., & Brewer, W. F. (1987). Theories of knowledge restructuring in development. *Review of Educational Research, 57*(1), 51-67.

Vosniadou, S., & Brewer, W. F. (1992). Mental models of the earth: A study of conceptual change in childhood. *Cognitive Psychology, 24,* 535–585.

Vosniadou, S. & Ioannides, C. (1998). From conceptual development to science education: a psychological point of view, *International Journal of Science Education, 20*(10), 1213-1230.

Vosniadou , S., Ioannides, C., Dimitrakopoulou, A., & Papademetriou, E. (2001). Designing learning environments to promote conceptual change in science. *Learning & Instruction, 11*, 381-419.

Vosniadou, S., Skopeliti, I. & Ikospentaki, K. (2004). Modes of knowing and ways of reasoning in elementary astronomy, *Cognitive Development, 19*, 203-222.