Children's ideas of changes in the state of matter: solid and liquid salt

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ABSTRACT
This research examines children’s (ages 12-13) ideas of changes in the state of matter of salt. Children construct ideas of physical phenomena and these ideas are serious to education. The change of state of matter is a transformation of substance due to the transfer of energy as heat. In several studies focused on children's ideas we find that these representations are often incompatible with the scientific model. In this research, where we studied the ideas of the melting and coagulation of the salt attended 104 children aged 12 to 13 years. The results of an interview show that these children use different types of ideas, the majority dominated by the nature of the substance under study.

Indexing terms/Keywords
Change of matter, liquid and solid salt, primary education, children’s ideas
THEORETICAL FRAMEWORK

Research in Science Education explores in some detail the ideas and misconceptions about science that are held by learners. It is known that these ideas are very often at a distance or opposed to models used for the teaching of the Natural Sciences (Ravanis, & Papamichæl, 1995; Ravanis, Papamichæl & Koulaïdis, 2002). That is why much weight is given to their detection as well as their treatment, which, through properly organized teaching interventions, leads to new ideas compatible with those of the models that are used for the instruction of the Natural Sciences.

Research associated with matters of comprehension of concepts and phenomena relative to heat and temperature has yielded interesting results concerning children's mental ideas stretching from preschool to their graduation from school. Important problems detected in the period of up to twelve years are the confusion of the concepts of heat and temperature, the recognition of temperature as an inner property of a body, the existence of warm and cold bodies by nature, the conception of "cold" and "warm" as distinguishable entities and the ambiguity concerning the thermal relationship between an object and its environment (Tiberghien, 1983; Stavy & Stachel, 1985; Stavy, 1990; Kesidou, Duit & Glynn 1995; Harrison, Grayson & Trefaust, 1999; Tytler, 2000).

As indicated by the related literature both the essential difficulty that children from 5 - 13 years old have in accepting the connection between the state of the materials and their temperature and the general framework of thermal balance, lead to a completely phenomenological approach of changes in states of matter (Osborne & Gosgrove, 1983; Laval, 1985; Zimmermann-Asta, 1990). This owes to the fact that children face specific situations and problems. This approach leads children's thinking to the following basic misconceptions: “as long as a body of water is heated, it's temperature rises, a substance's temperature cannot exceed it's boiling point, the ice's temperature is unchangeable, vaporization, liquefaction, solidification and melting are all terms exclusively related to water, the materials' freezing point is 0°C and their vaporization temperature is 100°C during changes in state of matter temperature is fixed” (Ravanis, 2013).

The majority of researches carried out internationally treat the subjects of water boiling and vaporization, the melting of ice or visible changes in the state of matter of substances familiar in everyday life. The empirical content of those familiar situations affects children's reasoning as the perceptive data of day to day life play a decisive role in the formation of their ideas concerning changes in state of matter. This is the exact reason why, in this research, we attempt, for the same children, to compare their mental ideas of change in the state of matter of materials such as ice and salt, which are familiar materials on the one hand, but on the other hand behave differently under conditions encountered in everyday life. For example, ice can very quickly change it's state of matter when heated with camping gas, while salt doesn’t and is also never encountered in liquid form.

We therefore attempted to study the ideas of children aged 12 to 13 concerning the problem of change in the state of matter of salt. Based on the research data we then attempted to elaborate the structural data of a teaching intervention intended to deal with the difficulties and obstacles that children's thinking faces (Martinand, 1986; Ravanis, 2013; Ravanis, Papandreou, Kampeza & Vellipoulou (2013)).

METHODOLOGICAL FRAMEWORK

Subjects and Procedure

The research sample was 104 subjects (51 boys and 53 girls 12-13 years old). Each student was interviewed independently. The tracking of children's ideas was carried out with individual guided interviews. Each interview lasted about 10 minutes. Three virtual tasks were presented to the children. The questions posed to the children concerned the recognition of the results of heating and freezing of a quantity of salt. The interviews were carried out in a room inside of the schools. We will subsequently present the tasks based upon which we requested answers from the children, a categorization of the ideas that we formed, as well as basic answers.

TASKS AND RESULTS

Task 1. Each children is posed with the question: “What will happen if we light a very powerful gas stove and heat a vessel containing salt?” With this question we attempt to ascertain if the subjects have any particular notion regarding the result of continuous heating of salt. In this question we sorted the answers among three categories;
a) Sufficient answers, where the melting of salt is clearly predicted. For instance; “The salt will then warms .... Could be like water .... fluid ...”.
b) Intermediate answers. In the answers that we rank as intermediate, the subjects, while they are actually referring to melting, they cannot formulate a concrete clarification. For instance, “do not know ..... because we heat the salt continuously ...... if it would melt .... The heat is not strong enough ......... I do not know ... I'm not sure”.
c) Insufficient answers. These are answers where no connection between heating and change in the state of matter is recognized or there is no mention of the rise of the salt's temperature. For instance; "...The salt will ever warms up ..... will become hot".

Task 2 (salt). Each children is posed with the question: “What will happen if we leave the vessel full of salt on the gas stove overnight, and come back in the morning?” The answers to this question were sorted among three categories;
a) Sufficient answers, where the subjects explain that continuous heating will lead to melting of the salt, i.e., they recognize a qualitative relation between heating and the liquefaction of salt. For example, “They melt salt ... It will be
fluid ... it looks like white water .......”.

b) Intermediate answers, where a connection between heating, increase in heating and change in the state of matter is realized, but it is unsure or incorrect. For example, S. 60; “...Salt .. is like ... is like powder ... Since the heat gets then .. could be converted to wet ..... But I'm not sure”.

c) Insufficient answers, where subjects don’t recognize that when salt is heated, its temperature will rise or they can’t establish a connection between heating and change in state of matter. For example, “…The salt will burn and blacken...”.

Task 3 (salt). Each child is posed with the question; “What will happen to the salt if we turn off the camping stove and come back in the morning?” Concerning this question, we expected differences corresponding to the ideas expressed in the two previous tasks. The answers were sorted as follows;

a) Sufficient answers, where the salt’s coagulation according to thermal balance is predicted, the exact same way its melting was predicted in tasks 1 and 2. For example, a subject who knew that the matters that were in the same area had the same temperature, responded directly; “The salt will cool slowly... The temperature will be the same everywhere in the room”.

b) Intermediate answers, where subjects fail to comprehend the salt’s liquefaction-solidification cycle, but are clearly referring to heat flow and thermal balance. For example, “It will grow cold... first of the surface will cool ...... will become cold.... and gradually the lower part will follow... because it is the part that’s close to the air... Tomorrow I do not know ......... can be a colder wet ......”.

c) Insufficient answers, where subjects don’t use the terms or concepts “heat transfer” and “thermal balance”. For example, “…The salt will cool .... especially at night .... and will warm up in the morning ..... But can keep the heat because it has gotten much ......”.

In the following table we present the frequency of the subjects’ answers in the three tasks that were introduced.

<table>
<thead>
<tr>
<th>Children’s Ideas</th>
<th>Task 1</th>
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<tr>
<td>Intermediate</td>
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<td>40</td>
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<tr>
<td>Insufficient</td>
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DISCUSSION AND IMPLICATIONS FOR TEACHING

In the research presented in this article, we tried to trace the ideas of students 12-13 years old concerning the melting and coagulation of salt. Even if this material is familiar and encountered in day to day life, its behavior in conditions of prolonged heating creates discernible children’s ideas.

In the first two tasks, where the subject is liquefaction of the salt, only 1 out of 10 children can predict the transition from solid to liquid state. In the third task, where the subject is the behavior of the hypothetically liquefied salt when it reach the usual environment temperature, only 3 out of 10 children were able to predict the transition from liquid to solid state. Furthermore, it is of particular interest that in all of the tasks, 3-4 out of 10 children hesitantly and with a degree of instability tends to answers that comply with the scientific model used in education. Also, it is particularly interesting that, the majority of the subjects don’t seem to be able to approach the issue of change in the state of matter.

From both a pedagogic and an instructive point of view, these data lead us to two remarks. The first one relates to the kind of cognitive impediment that children’s thinking faces in the age of 12-13. “It is therefore revealed that the primary difficulty concerning the change in the state of matter is the issue of the thermal balance restoration mechanism between two bodies, namely the heat transfer from the warm one to the cold one. This procedure is behind every change in the state of matter and is essentially a prerequisite to the familiarization with the sense and its generalization. The second observation is based on the need to construct set rules in the children’s thinking about the changes in the state of matter of all materials, in other words the recognition of the normalcy of the reversible course solid-liquid-gas” (Ravanis, 2013).

The findings of this research are well-matched with those of similar researches (Laval, 1985; Stavy & Stachel, 1985; Zimmermann-Asta, 1990). Truly, we have encountered almost all of the difficulties listed in those researches, simply based on interviews on three virtual tasks that were presented to the subjects without them being realized. The main obstacles for the students of that age are as follows; (a) each substance is in a “normal” state, regardless of temperature, (b) the absence of recognition of the general power of thermal balance and (c) temperature is a property of matter and not a product of its relationship with the environment.

So, the questions raised by the researchers are related to the possibility of developing innovative teaching interventions based at ideas and obstacles that students form regarding the change of matter. Indeed those obstacles need special instructive treatment, as we know that the transformation of students’ mental ideas is not arbitrary. However, within the
frameworks of research in Science Education we also know that, utilizing a systematic guidance, we can transform children’s thinking. From this aspect, a sequence of subjects and activities could go through the following phases:

- All materials, if left for a prolonged period of time in an environment with a steady temperature, will reach that temperature.
- The change in the state of matter that depends on its change of temperature is a stable and reversible procedure, regardless of the nature of the substance, which as far as its quality goes, remains the same.
- When in normal environment temperatures, we are not able to establish the changes in the state of matter of familiar materials. For it to happen, we need the creation of special conditions.

Finally, in this discussion we need to also pay attention to the stability of the temperature during the change in the state of matter, a subject particularly discussed in the similar bibliography. This phenomenon is semi-quantitative and is difficult to approach, as children that are 12-13 years old cannot sufficiently use a microscopic model of interpretation, which is necessary. Therefore, it does not constitute as a phenomenon fit for discussion at this stage.

Our research is now directed on the one hand to the study of the development of the ideas of children from 10 to 15 years old on the change of the state of matter, and on the other hand to the creation of teaching approaches for a first initiation of primary and secondary education students in qualitative and quantitative phenomena of change in the state of matter.

REFERENCES


