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Transforming 5-Year-Old Children's Mental Representations of Melting: A Storytelling Approach

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Abstract. The current paper presents the results of an investigation on the mental representations of children aged 5-6 years for the melting of everyday materials. In the research, the representations of the children for the melting of ice, butter and chocolate were studied in a pre-test with three tasks. Subsequently, a teaching intervention was performed based on a storytelling approach using the ancient Greek myth of Icarus, whose wax wings with which he flew in the air melted when he approached the sun. Finally, in a post-test, the children's representations after the teaching intervention were studied. The results of the research showed that children have made significant progress in the post-test as the majority of them recognize heating as a factor in melting the above materials.

INTRODUCTION

Over the last 40 years, a research stream has been developed in an interdisciplinary framework across Science Education and Early Childhood Education [1, 2]. In this context, the mental representations of children aged 3-8 years are explored and recorded in various issues such as plant development [3], cloud formation [4], shadows creation [5], energy [6], electricity [7] etc. Science educators transform these representations through appropriate teaching processes along the age and school level of children [8-12]. Due to the diverse developmental level of children, teaching interventions are often based on tools that draw directly from the sociocultural context: telling real or fictional stories, myths and fairy tales, dramatizations, play, etc. [13-16]. These approaches have a dynamic plot and often incorporate storytelling to stimulate children's imagination, emotions and interest [17-20].

A distinct research area that seems to be of particular interest in Early Childhood Science Education is that of thermal phenomena [21, 22]. Across a large variety of thermal phenomena, research seems to pay more attention to those that deal with changes in the state of matter, probably because these are associated with everyday natural phenomena such as clouds, rain, snow, or water cycle.

The issue of changes in the state of matter along children's thinking aged 3-8 years has been the subject of a number of studies. In these studies, the researchers mainly deal with the way children conceptualize water evaporation. Their findings present naïve mental representations of young children that create significant barriers to learning process such as the role of water heating, the mechanism of transition to the gaseous state and the maintenance of the amount of water in gaseous form [23, 24]. However, in some studies, the attempt to overcome certain obstacles of young children's thinking about evaporation, seemed to be possible as it was based on teaching interventions that focused on simple experiments with the emphasis given on children's difficulties [23-27].

Research moved along this line toward the issue of melting. In particular, Cruz-Guzmán et al. [28] worked with children aged between two and four years old and in a 'question-prediction-testing' teaching intervention through sequences, found that it is possible to evolve children's reasoning on the notions of melting and coagulation of everyday materials as long as they are conceptualized as effects of the actions 'to heat' and 'to chill'. In another study, the mental representations of children aged between five and six years old were studied, regarding the difficulty of recognizing the possibility of melting salt, as children deal with it in a daily basis as a solid state material [29]. In the

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perspective of the possibility of constructing a precursor model in the thinking of 5-6 year old about water state changes [30], it was found the difficulty of children to predict melting in the case of warming ice cubes, in contrast to the ease with which they connect heating with melting ice when actively participating in the realization of a simple experiment. From a sociocultural perspective, children aged 4-7 were asked to describe the melting process along a teaching intervention on the issue of melting and molten materials [31]. The analysis of children's drawings revealed a series of categories regarding the transition from solid to liquid state and the material that was transformed from solid to liquid.

In the current research, an attempt was made to investigate the mental representations of a group of children aged about 5 years old on the subject of melting materials and to transform these representations through teaching intervention that was based on Greek mythology, that is the myth of Icarus.

METHODOLOGY

Sample

The study involved 111 children (52 boys and 59 girls). The mean age of the children was five years and three months (S.D. 2 months). The children attended eight public kindergartens in an urban area in the city of Patras in Greece. On an initial visit to the schools, we invited children to play with us and listen to a nice story. We randomly selected half of the children who responded positively to our invitation. In these schools, children often participate in activities from the Physical Sciences, nevertheless having planned with their teachers, there were no activities in their classrooms on the changes of matter. The research was conducted by kindergarten teachers-researchers.

Design

The research is qualitative in nature. The research was conducted through individual semi-structured interviews. During the interviews the discussions with children were based on questions in three tasks on the melting of everyday materials. More specifically, in three relevant tasks children were asked to predict the melting of ice, chocolate and butter in conditions of intense heating; that is in conditions that children do not come across often in everyday life. In each kindergarten we were given an isolated room for conducting interviews. Conversations with children were recorded and converted into texts. Non-verbal behaviors were also recorded through the usage of a specially designed protocol. The findings from the analysis of the data helped to organize the narration of the myth that followed. The teaching intervention took place 15 days after the pre-test and included the narration and discussion of the myth of Icarus in which the melting of the wax wings occurred due to the intense heating by the sun. In the post-test the same projects along with the pre-test were used and the data were analyzed in the same categories. (Figure 1). The results of pre- and post-test were studied comparatively.

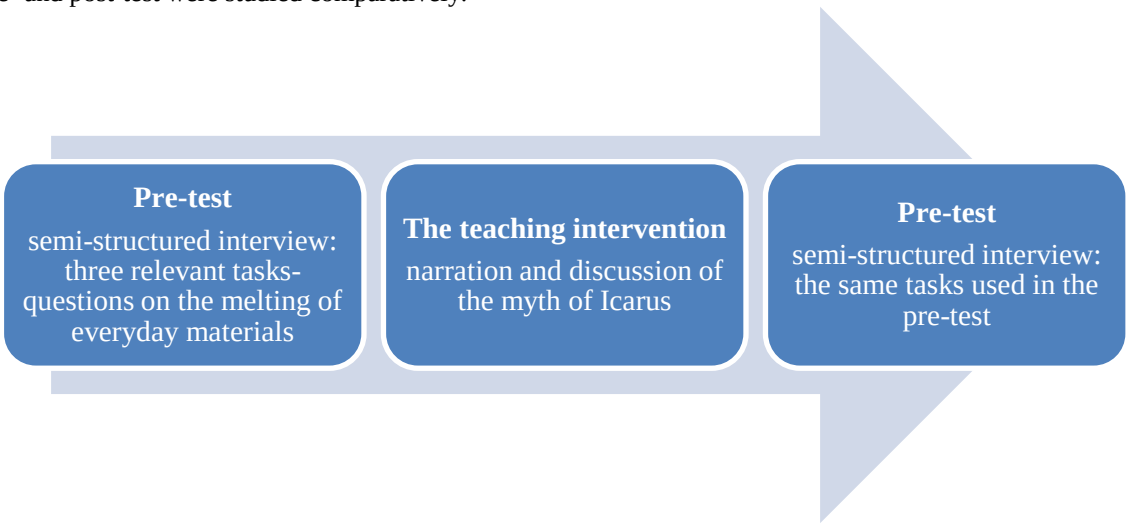

FIGURE 1. The research design

The analysis and classification of responses before and after the teaching intervention were evaluated by two different researchers, among whom there was more than 90% agreement. Where there was disagreement, a third independent researcher intervened.

Pre- and Post-tests

Three tasks were used to obtain children's representations of the melting of three materials. In all three tasks everyday materials were used. However, it was suggested to heat them in conditions that are not common in everyday life in order to avoid descriptions based on children's experience. In all three projects, predictions were requested without any experimentation.

Task 1. We present to children some ice cubes and ask them to predict what will happen if we heat them in the flame of a camping-gaz.

Task 2. We present to children a piece of butter and ask them to predict what would look like if we placed it in the lighted oven of an electric stove.

Task 3. We present to children a chocolate and we ask them to tell us what would like if we left it in the sun.

Teaching intervention

The didactic intervention was based on the myth of Icarus: Daedalus, Icarus' father, constructed wax wings in order to escape from prison. These wings were attached to their shoulders so they could fly. However, Daedalus warned Icarus not to get too close to the sun as the heat would melt the wax wings. Icarus did not obey his father's advice, flew very high and approached the Sun. As a result, the wing candle warmed up a lot, the wings melted, and Icarus fell into the sea and drowned.

Having discussed with the children about the myth, the kindergarten teacher showed to them a 3-minute video in which the story was narrated along with attractive animations suitable for children of this age (https://www.youtube.com/watch?v=n1OFt5xUNU8). After watching the video, the teacher emphasized the construction of the wings from wax and the melting of the wings due to Sun heating. She also asked children to talk about other materials capable of melting along heating and discussed specific examples such as ice-cream, avoiding any reference to ice, chocolate and butter.

RESULTS

During the research process, the mental representations expressed by children through their responses into the 3 tasks in the pre- and post-test. Children's answers were classified into three distinct categories based on their difference from the quality model used in education:

- Sufficient responses. In these answers children can predict and explain melting based on the heating of the material. Of course, their answers are qualitative in nature, given their level of development.
- Intermediate responses. In these answers, children are able to predict melting, without referring to any kind of thermal changes in the environment though.
- Insufficient responses. In these answers, children either make descriptions that are not related to the phenomenon or answer directly that they do not know.

From a quality context, all three categories of answers were traced in the pre- and post-test, in different frequencies though.

Task 1

In the first task, children faced a hypothetical situation with which they are unfamiliar; that is the heating of ice in the intense flame of a camping-gaz. They were asked to answer what will happen to the ice cubes during the heating process. In what follows indicative examples of children's responses as well as a table with the frequencies of their responses are presented (Table 1).

Sufficient responses. In these responses, children associate melting ice with heating. For example, '*This is how we warm the ice cubes… they will melt*' (Pupil 65, pre-test). '*They will become water from the heat of the fire… like Icarus…*' (P. 31, post-test).

Intermediate responses. In this category of responses children make predictions about melting, albeit hesitantly, but do not make a satisfactory connection to heating. For example, '*The ice cubes will melt when you take them out of the fridge*' (Researcher: *Why? How do you think it*?). '*This is how ice cubes operates in order to cool us*' (P. 91, pre-test), '*The ice cubes that we put in the orange groves always melt… so, these will also melt*' (Researcher: Why? How do you think it?). '*As everything melts…. This is how they will melt, too'*. (P. 107, post-test).

Insufficient responses. In these responses children do not predict the melting of ice. For example, '*I do not know…. They may turn black from the fire…*'(P. 7, pre-test), '*I do not know if they melt in fire…. I know if you put them in a glass…*' (P. 36, post-test).

TABLE 1. The frequencies of children's responses to Task 1.

	Pre-test		Post-test	
	f	%	f	%
Sufficient	15	13.5	74	66.7
Intermediate	79	71.2	31	27.9
Insufficient	17	15.3	6	5.4

Task 2

In the second task, children were asked to think about what would happen if a piece of butter was placed in the lighted oven of an electric stove. It should be noted that from the beginning of the task it was clarified that children recognized the high temperature inside the oven. In what follows indicative examples of children's responses as well as a table with the frequencies of their responses are presented (Table 2).

Sufficient responses. In these responses children associate melting butter with heating in the oven. For example, '*The oven is very hot… we cook the food over there… the butter will melt in order to place it in the sweets*' (P. 66, pre-test), '*As everything melts in the sun and over great heat, so the butter will also melt*' (P. 93, post-test).

Intermediate responses. In the responses of this category children seem to understand the change of state but despite the insistence of the researchers they do not refer to heating. For example, '*Probably it will melt…. I do not know for sure…*' (Researcher: '*Could you explain to me your thoughts?*'). '*I think it will melt*'. (Researcher: '*Why do you think that?*'). '*You mean why butter melts?*' (Researcher: '*Yes, why does it melts?*'). '*When we take it out of the fridge*' (Researcher: '*Here that we placed it in the oven?*'). '*Because it's out of the fridge*' (P. 11, pre-test), '*I have seen it melt*' (Researcher: '*Have you seen it melt when it is placed in the oven?*') '*No, when we take it out…. but sometimes it remains on the table as it is so we put it back in the fridge…*' (Researcher: Inside the lighted oven, what do you think it happens?). '*It can melt there too… it is butter!*' (P. 87, post-test).

Insufficient responses. In these responses children do not recognize the melting of the butter. For example, '*It will be there on the table. We cut it with a knife*' (Researcher: '*Yes… but now we have placed it in the lit oven. What do you say is going on there?*'). '*Nothing…. it will heat up and we will take it out again whenever we want*' (P. 100, pre-test), '*The butter will heat up and dry… I do not know if we can eat it later or if it spoils…*' (P. 55, post-test).

TABLE 2. The frequencies of children's responses to Task 2.

	Pre-test		Post-test	
	f	%	f	%
Sufficient	11	9.9	59	53.2
Intermediate	35	31.5	18	16.2
Insufficient	65	58.6	34	30.6

Task 3

In the third task, children were asked what would happen if a chocolate was left in sun. In what follows indicative examples of children's responses as well as a table with the frequencies of their responses are presented (Table 3).

Sufficient responses. In these responses children recognize the melting of the chocolate due to the sun. For example, '*Chocolate will heat up and melt… but we have to leave it there for a long time*' (P. 23, pre-test), '*It's like a wax... it will melt due to heat*' (P. 78, post-test).

Intermediate responses. Changes in chocolate seem to be recognized in this category responses, however these changes are related to other quality characteristics. For example, '*It will break. If we leave it in the sun we will not be able to eat it and we will have to throw it away*' (Researcher: '*Why? How do you think it?*'). '*Food spoils in the sun*' (P. 107, pre-test), '*It will spoil and probably will become soften…*' (Researcher: '*When you say it will become often what do you mean?*'). '*It will look like spoiled*' (P. 71, post-test).

Insufficient responses. In these responses, children do not associate chocolate exposure in the sun with change of state. For example, '*Nothing will happen…. it will just be a little warmer*' (P. 32, pre-test), '*It will not become like Icarus wings… It will be the same chocolate*' (P. 55, post-test).

TABLE 3. The frequencies of children's responses to Task 3.

	Pre-test		Post-test	
	f	%	f	%
Sufficient	22	19.8	85	76.6
Intermediate	71	64	24	21.6
Insufficient	18	16.2	2	1.8

DISCUSSION

In the current study, an attempt was made to investigate the effectiveness of a teaching intervention based on an ancient Greek myth. The aim of the intervention was to transform the mental representations of children aged about 5 years for the phenomenon of melting. As the data analysis showed, during the pre-test only few children were able to connect melting with heating. Particularly, in the first Task 1-1.5/10 children manage to do this, in the second Task 1/ 10 and in the third Task, which deals with a fairly familiar situation, 2/10 children.

This finding is consistent with other studies [30] in which the issue of change of state of water in relation to thermal changes was studied. In some of these studies, attempts were made to transform the naive mental representations of children and to investigate the possibility of forming new representations compatible with scientific knowledge in a school context. However, in all these studies the dominant teaching approach was based on carrying out simple experimental activities [26, 27, 30]. In the present study, through a storytelling approach, it seems that it became possible to satisfactorily approach the melting of a number of everyday ingredients such as butter and chocolate since a large number of children were able to recognize, during the post-test, their melting through heating. Indeed, after the participation of children in the teaching intervention in the first Task there was an increase of sufficient answers by 53.2%, in the second Task by 43.3% and in the third Task by 56.8%

These findings underline the effectiveness of the storytelling approach, that is the placement of the myth of Icarus at the center of teaching intervention. Indeed, this approach offers special possibilities that are close to the routines and practices of this educational level as it allows young children to be introduced to the phenomena and concepts of Physical Sciences through the use of imagination and play. Undoubtedly this perspective requires systematic research work as it is not enough to invoke the practices that are familiar to young children. In conclusion, we could argue that alongside the constructivist approach that prevails in Science Education, perhaps a sociocultural approach could contribute to an early initiation of young children into the world of Physical Sciences.

In the context of Early Childhood Science Education, trying to move from naïve mental representations of children to precursor models, i.e. to elaborate entities compatible with the knowledge of Physical Sciences, requires a systematic effort and perhaps a combination of teaching practices [32]. The acceptance of such a perspective has consequences not only in the level of daily development of activities within the classroom but also in the basic and ongoing teacher training and design of curricula.

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