Approaching change of state in early childhood education: the design of a teaching intervention based on storytelling

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ABSTRACT
Eliciting preschool children's ideas in research, generally, and in science, particularly, necessitates the utilization of suitable methods that contribute to empowering children to share their ideas and experiences. In this paper we propose and discuss the potential of a research-based teaching intervention designed to foster preschool children's understanding of change of state and build a precursor model of melting and freezing. The proposed teaching intervention is based on the idea that storytelling provides a meaningful context for children, using a language within their experience. It also suggests to engage the children into drawing activities at various steps of the intervention, considering that drawing is a powerful tool to support children's expression of ideas in science and follow the development of such ideas. The paper discusses the possibilities that emerge from the proposed teaching intervention for the learning of scientific concepts, and in particular, the choices made to link storytelling, drawing activities and discussions with the children.

KEY WORDS
Early science teaching, children's ideas, change of state, storytelling, drawing

RÉSUMÉ
Recueillir les idées d'enfants de l'école maternelle pour la recherche, en général, et en science, en particulier, nécessite le recours à des méthodes adaptées afin d'encourager les enfants à partager leurs idées et expériences. Dans cet article, nous proposons et discutons du potentiel d'une intervention didactique basée sur la recherche et conçue pour des enfants de maternelle, pour favoriser leur compréhension des changements d'états et la construction d'un modèle précurseur de la fusion et solidification. L'intervention didactique proposée est fondée sur l'idée que la

narration fournit un contexte porteur de sens pour les jeunes enfants avec un usage du langage à leur portée. Il est aussi suggéré d'engager les enfants dans des activités de dessin à plusieurs moments de l'intervention, en considérant que le dessin est un outil intéressant pour encourager l'expression d'idée des enfants en sciences et suivre le développement de ces idées. L'article discute des possibilités qui émergent de l'intervention didactique proposée pour l'apprentissage de concepts scientifiques, et en particulier les liens entre la narration, le dessin et les échanges avec les enfants.

MOTS-CLÉS
Enseignement des sciences en maternelle, idées des enfants, changements d'état, narration, dessin

THEORETICAL FRAMEWORK

During last decades the importance of science in early childhood education is constantly highlighted. In this paper, we attempt to contribute in making closer links between educational research and practice and to address the need for effective teaching approaches regarding science topics in kindergarten. Therefore, we are proposing to discuss the potential benefits of a new teaching intervention considering a combination of methods (storytelling and drawing) in order to facilitate young children's thinking and learning. As Fleer & Hardy (1993, p. 69) mention "eliciting children's understandings depends upon the child's motivation to be involved in the interview or teaching program. Unless young children see some purpose in participating they will simply not become involved". In addition, increasing motivation, coupled with the sense of working together on a shared problem, reduces disciplinary problems and diminishes time-wasting distractions in the classroom (Arnold & Millar, 1996).

Storytelling and early science teaching

Storytelling can be used as a method to elicit children's understanding as well as a way of introducing science activities within a meaningful context as opposed to the abstract presentation of concepts. Therefore, it can be an appropriate mediator for young children in order to describe or explain natural phenomena. Storytelling offers the potential for effectively addressing the need to engage children's interest in a given science topic by providing a context, stimulating the children to share some ideas and using language that is within their experiences (Fleer & Hardy, 1993). In other words, it offers the double advantage of captivating children's attention related to their affective relation to stories, but also bringing them from this initial affective interest to a cognitive engagement related to the questions raised by the natural phenomena addressed in the story (Soudani, Héraud, Soudani-Bani & Bruguière, 2015).

The storytelling framework also provides a conversational approach facilitating children to get involved in authentic dialogue. This can also engage children as well as teachers in a common context of communication. In such context, children can "express freely" their ideas about science and natural phenomena amongst themselves or with their teacher (Papandreou, Kampeza & Vellopoulou, 2014). Teachers can use stories that emphasize particular aspects of a phenomenon. These stories may have chained structure or hierarchical progression (each unit building upon the previous) or may be open-ended so that the children can develop their own ideas (Kampeza & Ravanis, 2012).

Considering the educational process, storytelling provides a medium for ongoing instruction for the teacher and deepening science understanding for the children. Especially, young

children have the opportunity to express their ideas concerning scientific concepts and phenomena in a way that addresses their needs and they can further elaborate their understanding through the interdisciplinary perspectives that the story can integrate.

Drawing and early science teaching

Research has shown that drawing provides insights into young children's thinking. What children draw and how they draw "reflect the complexity of communication and sign systems in the communities they are reared and educated" (Anning & Ring, 2004, p.1). Drawing activity is open-ended and enables the relation between symbols and meanings. Young children frequently use oral speech when they draw, and they talk about their drawing; they provide explanations or narrate a story (Van Oers, 1997). Drawing can also become a discussion document between a group of children. So, there is a close relationship between drawing and thinking; when children draw they are engaged in a mental activity (construction of meanings through graphic symbols), and at the same time drawing supports the thinking process. It can "serve as a means for recalling and expressing previous experiences and knowledge, elaborating new information, and organizing all the above" (Papandreou, 2014, p. 93).

In the field of Early Science Education children's drawing activity is frequently used as a means for eliciting children's ideas (Delserieys, Impedovo, Fragkiadaki & Kampeza, 2017; Kampeza & Ravanis, 2012). Chang (2005) underlines the fact that using drawings during different phases of an inquiry can help children "revisit their learning and rethink what has been addressed" (p. 104). In addition, educators can use drawings to facilitate children's learning by keeping track of children's ideas and therefore being able to reshape and adjust curriculum plans and teaching strategies. Drawing seems to be a powerful tool, a medium for making children's perceptions externally manifest and available for reflection.

Children's ideas considering change in state of matter

Studying young children's ideas about natural phenomena has been a special field of research for Science Education for years. Usually young children need to develop a concept of material that is independent from the object so Rahayu &Tytler (1999) propose that teaching of materials in early primary school should be focused on physical change and more particular, on changes of state (melting and freezing). Ravanis (2013) argues that young children have difficulty in "accepting both the connection between the state of the materials and their temperature, and the general framework of thermal balance; this difficulty leads to a completely phenomenological approach to changes in states of matter" (p. 130). He stresses 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 body to the cold body. This procedure is behind every change in the state of matter and is essentially a prerequisite to becoming familiar with the concept and being able to generalize about it" (p. 135). In addition, the terms "heat" and "temperature" are commonly regarded by children as synonymous. Children also may not consider the importance of the surroundings, so understanding of thermal equilibrium, the process by which two objects initially at different temperatures come to a common final temperature, is necessary. Therefore, children do not always consider that objects in the same thermal environment will have the same temperature (Arnold & Millar, 1996).

Taking into account sociocultural approaches, which consider learning as a process of social co-construction of meanings, that take place through children's participation in meaningful contexts (Robbins, 2005) and the idea of a precursor model regarding the change of state of matter for preschoolers, which can be described as an intermediate mental scheme between children's

representations and a scientific explanation (Delserieys, Jegou, Boilevin & Ravanis, 2018; Lemeignan & Weil-Barais, 1994) we propose a teaching intervention that aims to engage children in the topic by posing specific tasks that address research-based difficulties.

METHODOLOGICAL FRAMEWORK

The methodological framework is derived from sociocultural perspective (Delserieys et al., 2017; Fleer & Robbins, 2003; Papandreou et al., 2014; Robbins, 2005) where attention is directed to the types of experiences children have in their world, the artefacts and cultural tools which are commonly used, and therefore, teaching is concerned with how to enable the everyday concepts that children develop through their experience with the world and the scientific concepts come together in meaningful ways. The proposed teaching intervention, based on storytelling and drawing, has the potential for gaining new understandings of how young children develop their thinking about a given concept. It is the first step of a larger research project intending to implement this teaching intervention in various preschool educational contexts.

The proposed teaching intervention uses a story developed by the authors for the purpose of the study. The story was originally deployed from an activity that was initially based on the work of Vellopoulou (2000) concerning educational activities in order to familiarize young children with science concepts. The objective is to develop a meaningful context where young children can be concerned with the nature of substances and the role of temperature in the state of materials, the role of heat in melting and that each of the materials retains its essential identity, even though the properties may change. We can regroup our main learning objectives in 4 categories (table 1): category 1 concerns objectives focusing on the factor of temperature, category 2 concerns the objectives focusing in the nature of the material, category 3 focuses on the factor of time, and category 4 concerns objectives that start to bring some characteristics of a scientific model to the phenomena of change of state (thermal equilibrium involving heat exchange and time, reversibility of the process). These characteristics can be thought as a first step in considering the development of a precursor model of heat and temperature for young children (Delserieys et al., 2018; Lemeignan & Weil-Barais, 1994).

The main steps of the story are presented in table 1, along with a brief description of main classroom activities and what is expected from the children in terms of drawing, collective discussion and experimenting. An imaginary environment is proposed with a "Land of Warm" (W) and a "Land of Cold" (C). This is used as a stimulus to engage children to reflect on what these lands would be like in order to focus children's attention on the factor of temperature; this is accomplished in a qualitative and intuitive way and not by actual references to temperature degrees, because previous studies have highlighted the difficulty for young children to use thermometers (Kampeza, Vellopoulou, Fragkiadaki & Ravanis, 2016). The use of two lands also opens the possibility of thinking journeys from one land to another. This is used as a stimulus to focus children's attention on the factor of time. Back and forth journeys are possible using the same material, different material, bringing new material from one land to another, etc. encouraging children to reflect on the conservation of mater in the physical process and the reversibility of the process.

Beyond the environment of the story, storytelling engages the characters to encounter some adventures, so both plot and science content are connected. In particular, the main character comes up against a new problem and the children must help the character solve it, in order for the story to progress. In this way, the children are actively engaged into the action of the story and motivated

in the acquisition of new knowledge and skills. In the proposed story, the main problem comes with a challenge (table 1, step 2) to bring in the land of Warm objects that are likely to melt in warm temperatures (ice-lolly, chocolate, butter). These objects and the experience of melting of these objects are likely to be part of children's familiar environment. As such, they can be used as a stimulus to find out what children already know and make them explore further their own experience of physical phenomena in everyday life. The story then follows the problems of a girl going in a quest to succeed in the challenge. Children are encouraged to propose solutions to help the character, to predict what will happen to the character. In these phases, experiments are proposed to support children's thinking in the story.

Drawing activities are proposed all along the story, with a total of 6 drawings. The first and final drawings serve as benchmarks to identify what children know about exposing different materials to high temperature (warm) in contrast to low temperature (cold) before and after the activities (in that sense there will be a kind of pre and post recording although this perspective does not follow a constructivist view where the focus is on what is 'lacking' in children's thinking, and what is 'corrected' through the teaching process). It has to be noted that most drawings are followed by discussions. The drawings are, therefore, used to trigger the exchanges and foster children's thinking by comparing differences or disagreements between different drawings, to encourage children to revisit their learning as suggested by Chang (2005). We also stress that drawing 5 echoes the drawing that the character of the story does. In the story, the drawing plays a major role in recording the previous states of the objects and helping to succeed in the challenge. We believe this contributes to giving meaning to the drawing and recognize the drawing, not only as a way of expression, but also as a way of recording important information (Papandreou, 2014).

TABLE 1

Overview of the proposed teaching intervention with a story setting in the "Land of Warm" (W) and "Land of Cold" (C) highlighting children's activity related to drawing and associated learning objectives

Steps of classroom activity related to the steps of the story	**Children's activity** ***Help for drawing***	**Steps of learning objectives (numeration refers to the 4 categories mentioned in the text)**
STEP 1: Introduction to the problematic situation - Once there was a land of W with a prince and a challenge in order to get married. Description of the land of W Description of food and drinks in the land W	**Draw 1**: Draw food and drinks that can be found in the land of W and food and drinks that cannot be found in the land of W (*paper with 2 columns*) **Discussion 1**: Collective discussion on food and drinks in the land of W, based on a selection of drawings from Draw1. Which food and drinks cannot be found in the land of W? Why?	**Obj 1.1** - Provoke children think that the state of a material depends on the temperature of the environment **Obj 1.2** - Recognize that the objects placed in an environment have the same temperature than this environment **Obj 1.3** - Recognize that some objects cannot exist in a specific temperature

STEP 2: Initial predictions – Challenge of the prince: bring him an ice-lolly, a butter star and a chocolate in the shape of a heart. Discussion on the objects that the prince wants and the fact that they were never seen in the land of W. Why is it a challenge?	**Draw 2:** Provide *images of the objects* and ask children to draw these objects in the land of W. «Draw what do you believe happens to them in the land of W?" **Discussion 2:** Collective discussion based on a selection of Draw2 – what are the objects made of? Why they were never seen in that state in the land of W? What do these objects look like in the land of W?	**Obj 2.1** - Differentiate the objects and the material they are made of. **Obj 1.3** - Recognize that some objects cannot exist in a specific temperature **Obj 4** - Help children focus on "heat" as the reason for melting **Obj 2.2** - Help children verify that the nature of substance doesn't change because of melting - Help children overcome the idea that whatever material melts becomes "water"
STEP 3: Journey to land of C A clever girl goes to a land where she believes there is a solution to the challenge. She brings with her juice and a sweet brown soup in her heart shaped box for the journey. As she travels inside the new land, it gets colder. She makes a stop but then she can't eat and drink because juice and soup have become hard. Why? What can she do? Back and forth journeys can be considered to make it liquid again, to add a stick to make a lolly, etc. It is established that this other land can be called the land of cold. She meets a citizen from the land of C who gives her hard butter.	**Discussion 3:** Collective discussion – what could be different in that land that could help the girl find what she needs. **Draw 3:** Make a drawing that shows how they think the girl can taste the juice and soup (*white paper*) **Discussion 4:** Collective discussion based on a selection of Draw3. How does the girl taste the juice and soup? Why? Experiments to make ice-lolly, chocolate heart and butter star	**Obj 1.4** - Recognize the temperature as being the factor that changes between the 2 lands **Obj 2.3** - Identify the change of state (liquid to solid) of different materials **Obj 2.4** - Recognize the conservation of matter in the process **Obj 1.5** - Identify that this change depends on temperature **Obj 2.2** - Help children verify that the nature of substance doesn't change because of melting
STEP 4: Journey back to land of W: The girl realizes she has the ice-lolly, the chocolate heart and know how to make the butter star. So, she travels to the castle of land of W. Her journey takes	**Draw 4:** Draw what you think the 3 objects will look like at different moments of the journey of the girl (*paper with separations and timelines to help children organize their drawings*).	**Obj 3.1** - Recognize that the process takes time **Obj 3.2** - Recognize that some material will melt faster than other depending on temperature

time and, in her journey, she makes drawing of the objects. She sees changes in the objects – the word "melted" can be introduced in the discussion. When the girl reaches the castle, everything has melted.	**Discussion 5** Collective discussion based on a selection of Draw4. What changes can be observed from the land of C to the land of W? Why? Make an experiment to reproduce (model) what happens to the 3 objects when the girl travels from the land of cold to the land of warm **Draw5:** Drawings associated to the experiment: initial state, observation of changes, final state (*white paper*)	**Obj 4** - Focus on the elements of time and heat that are necessary for melting
STEP 5: Journey to land of C Using the drawings, the girl convinces the prince that she can have these objects again if he follows her in the land of C. They decide to get married in the land of C. Lots of people followed and brought food to the land of cold for the wedding.	**Discussion 6** Collective discussion based on Draw4 and Draw5 to identify the steps of changes and address the concept of reversibility **Draw6:** Take the Draw1 and draw what will happen to the food and drinks of the land of warm when they reach the land of cold.	**Obj 4** - Recognize that change of state is a reversal process **Obj 2.5** - Recognize that change of state does not apply only to water, but to any material

It is worth noticing that in most of research in science, young children participate in interviews prior and after the teaching intervention. The design of the present teaching intervention integrates children's discussion and drawings that serve a double purpose. On one hand, we have stressed the interest in children's development and learning of science. On the other hand, the choice of integrating drawing is also strongly influenced by its methodological potential in terms of collecting children's ideas along the activities (Delserieys et al., 2017). It can be seen as an opportunity to find out more about the children's thinking in progress and discuss the scientific ideas more extensively. In this perspective, we will examine extracts of conversations and drawings completed according to the sequence of the story in an attempt to analyze children's ideas accompanied with signs and tools (e.g. arrows indicating correlations or ways of movement) that contribute to make sense of the relationships and causalities among the specific elements.

The implementation of the proposed teaching intervention is still in progress and data are going to be collected from two classrooms in two different countries (Greece and France).

DISCUSSION

Even though understanding children's ideas for natural phenomena is crucial for science teaching, since they provide valuable information considering the planning of activities in early science,

different approaches of research in science teaching and learning in early childhood education have been developed. Although the constructivist perspective has been a powerful influence in science education and continues to hold a significant position in research as it contributed to the identification of many ideas that children hold (using terms as misconceptions, alternative views, naïve ideas), in recent years there is another research perspective that stresses the importance of understanding children's way of communication and thinking (Fleer & Robbins, 2003; Robbins, 2005). Sociocultural theory, originating in the cultural-historical work of Vygotsky and his colleagues emphasizes that it is through contexts, actions, meanings and involvement in activities with others that development occurs. Special attention is paid to how specific tools can transform knowledge, rather than transmit knowledge (Fleer & Robbins, 2003; Robbins, 2005).

In addition, the inclusion of preschool children's ideas in research necessitates the utilization of suitable processes that contribute to empowering children to share their knowledge, understanding and experiences. "For preschool children who may have less confidence in articulating abstract concepts using only words, tapping into a range of child-friendly methodologies and methods may encourage them to construct and articulate their views with greater ease" (Tay-Lim & Lim, 2013, p. 68). In this perspective, the proposed teaching intervention combines different tools and processes (story, drawing, discussion, experiment) embedded in a meaningful context for preschoolers. This methodological approach is expected to act as a means for advancing children's thinking; the story triggers their imagination and interest, while talking with the children concerning their drawings created in the framework of the story moves beyond the traditional procedure of "extracting facts" from them. The focus is shifted from recording what an individual child knows at a particular point in time, to a broader and richer view of the process of a child's development of scientific thinking.

Drawings have a unique dynamic; they can't be "read" in the same way as a piece of writing or be easily understood out of context. Asking children to draw within the story framework is believed to provide a more coherent context for relating different aspects of the topic at issue. As Hope (2008 p. 44) underlines "it (drawing) involves process thinking: thinking within a system, yet also with or through the system [...] thinking about the content and the meaning that is being conveyed as the drawing develops substance and form."

Furthermore, the proposed teaching intervention integrates methodological orientations on how further data collection can be set in a classroom situation. Future research is planned within a qualitative approach based on observing the activity of the children during a set of activities, and moving out from a strict pre/post test approach. In the context of preschool education, a more structured interview technique may fail to unlock young children's potential as thinkers, while the use of the story combined with the drawing activity may help teachers or researchers engage in a meaningful interaction with young children. In that, the successive drawings of a child can serve as valuable traces of his/her development and a meaningful media to analyze for the teacher (Delserieys et al, 2017). The interaction between the teacher and the children also plays a crucial role in the construction of the topic in question. For this intervention to be effective, it has to be supported by the teacher who will encourage the children to produce iconic representations as well as oral references to the specific topic.

Drawings will be also connected to an experiment as a means to enhance children's thinking acting as "an analogical bridge between the real world of observation, the inner world of the imagination, and the realm of conscious seeing, thinking and feeling" (Hope, 2008, p. 47).

Finally, the story developed for this research has a specific sequence of steps in order to focus children's attention on specific factors of the physical phenomena addressed in the teaching intervention. Although it is placed in an imaginary setting, it has the potential to trigger questioning

of the real world for children that age (Soudani et al., 2015) and is, therefore, set to help them progress in their interpretation of reality. As such, the story reinforces building causal relations (between temperature and change of state) to encourage children to think scientifically of a phenomenon they are likely to encounter in everyday life (Delserieys, et al., 2018). This can serve as first precursors to later develop models of heat and temperature to explain change of state of materials.

The proposed teaching intervention offers a richer and multi-modal context for preschoolers in terms of constructing a precursor model on changes of state of matter. It can motivate children mentally, provide different ways of expressing ideas (orally, iconic) and help children organize their experiences, arrange events in order of time, and make structures and patterns, thus approaching more abstract scientific thinking.

REFERENCES

Anning, A., & Ring, K. (2004). *Making sense of children's drawings*. Berkshire: Open University Press.

Arnold, M., & Millar, R. (1996). Learning the scientific "story": A case study in the teaching and learning of elementary Thermodynamics. *Science Education, 80*(3), 249-281.

Chang, N. (2005). Children's drawings: Science inquiry and beyond. *Contemporary Issues in Early Childhood, 6*(1), 104-106.

Delserieys, A., Impedovo, M.-A., Fragkiadaki, G., & Kampeza, M. (2017). Using drawings to explore preschool children's ideas about shadow formation. *Review of Science, Mathematics and ICT Education*, *11*(1), 55-69.

Delserieys, A., Jegou, C., Boilevin, J.-M., & Ravanis, K. (2018). Precursor model and preschool science learning: Efficiency of a teaching intervention on shadow formation. *Research in Science & Technological Education, 36*(2), 147-164.

Fleer, M., & Hardy, T. (1993). How can we find out how 3 and 4 year olds think? New approaches to eliciting very young children's understandings in science. *Research in Science Education, 23*, 68-76.

Fleer, M., & Robbins, J. (2003). "Hit and run" research with "hit and miss" results in early childhood education. *Research in Science Education, 33*(4), 405-431.

Hope, G. (2008). *Thinking and learning through drawing in primary classrooms*. London: Sage.

Kampeza, M., & Ravanis, K. (2012). Children's understanding of the earth's shape: an instructional approach in early education. *Skholê, 17*, 115-120.

Kampeza, M., Vellopoulou, A, Fragkiadaki, G., & Ravanis, K. (2016). The expansion thermometer in preschoolers' thinking. *Journal of Baltic Science Education, 15*(2), 185-193.

Lemeignan, G., & A. Weil-Barais. 1994. A developmental approach to cognitive change in mechanics. *International Journal of Science Education, 16*(1), 99-120.

Papandreou, M. (2014). Communicating and thinking through drawing activity in early childhood. *Journal of Research in Childhood Education, 28*(1), 85-100.

Papandreou, M., Kampeza, M., & Vellopoulou, A. (2014). Eliciting children's ideas about concepts concerning science in kindergarten; techniques and main processes. In P. Kariotoglou & P.

Papadopoulou (Eds.), *Science and environment in early childhood education. Prospects and proposals* (pp. 157-176). Athens: Gutenberg (in Greek).

Rahayu, S., & Tytler, R. (1999). Progression in primary school children's conception of burning: Toward an understanding of the concept of substance. *Research in Science Education, 29*(3), 295-312.

Ravanis, K. (2013). Mental representations and obstacles in 10-11 year old children's thought concerning the melting and coagulation of solid substances in everyday life. *Preschool and Primary Education, 1*(1), 130-137.

Robbins, J. (2005). Contexts, collaboration, and cultural tools: A sociocultural perspective on researching children's thinking. *Contemporary Issues in Early Childhood, 6*(2), 140-149.

Soudani, M., Héraud, J.-L., Soudani-Bani, O., & Bruguière, C. (2015). Mondes possibles et fiction réaliste. Des albums de jeunesse pour modéliser en science à l'école primaire. *Recherches en Didactique des Sciences et des Technologies, 11*, 135-160.

Tay-Lim, J., & Lim, S. (2013). Privileging younger children's voices in research: Use of drawings and a co-construction process. *International Journal of Qualitative Methods, 12*, 65-83.

Van Oers, B. (1997). The narrative nature of young children's iconic representations: Some evidence and implications. *International Journal of Early Years Education, 5*(3), 273-245.

Vellopoulou, A. (2000). *Learning and creativity. Educational activities enabling children's familiarization to Physics concepts*. Athens: Ellinika Grammata (in Greek).