



## CONCEPTUALIZING SOLID IN LIQUID DISSOLUTION IN EARLY CHILDHOOD EDUCATION SETTINGS: A SOCIO-CULTURAL APPROACH

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### **Abstract:**

In this study, we attempt to exhibit the importance of the socio-cultural environment for the conceptualization of the dissolution of solids into liquids by 5 to 6 years old children. Through the organization and encouragement of *conceptual play* processes within every day educational reality in kindergarten, we examine whether children are able to form reasoning on dissolution, to recognize this phenomenon in their familiar environment as well as to search for processes that facilitate the ascertainment of materials' solubility or dissolubility. In this article, we present data collected from conversations between two children in an urban-area kindergarten in Greece. The conversations were developed during the children's *conceptual play* within the period of one week. The data were collected through recordings and field notes during semi-structured interviews. Qualitative data analysis exhibited that the social and cultural reality of children is dynamically present in their play and constitutes the source of development for young children's thinking regarding the phenomenon of dissolution.

**Keywords:** socio-cultural approach, conceptual play, preschool age, early childhood, science education, dissolution of a solid substance in a liquid solvent

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## 1. Introduction

During the last twenty years, part of Science Education Research (Boilevin, 2013) has turned its attention to children aged 4 to 8 years old, forming a concrete scientific research field recognized as Early Childhood Science Education Research. Research results as well as research applications in this field has exhibited that, using different pedagogical strategies, it is feasible to lead young children's thinking towards a kind of reasoning that is compatible with scientific knowledge as exists in schools programs (Ravanis, 2000; Hadzigeorgiou, 2002; Christidou & Hatzinikita, 2006; Kampeza, 2006; Kambouri, 2011; Kampeza & Ravanis, 2012; Koliopoulos, Gouskou & Arapaki, 2012; Ergazaki & Zogza, 2013; Delserieys, Jégou & Givry, 2014; Kambouri & Michaelides, 2014; Fragkiadaki & Ravanis, 2015; Georgantopoulou, Fragkiadaki & Ravanis, 2016; Kampeza, Vellopoulou, Fragkiadaki & Ravanis, 2016; Malleus, Kikas & Marken, 2017). These theoretical and empirical based studies have led to the development of different pedagogical strategies for conducting science activities in kindergarten. These pedagogical strategies were characterized as empiricist, piagetian, and socio-cognitive oriented strategies (Ravanis, 2010). Regardless the fact that these research as well as pedagogical approaches have yielded interesting research and educative results, they have lately been subject to criticism. This criticism centers on ignoring or downplaying of specific developmental characteristics and processes such as child's motivation, imagination, creativity, multiple social interactions, cooperation, tone of communication, social practices, as well as child's every day experience. These elements have been underestimated although the dynamic potential outcomes to the development of children initial reasoning towards the formation of interpretive models compatible with the scientific one used in education. However, the study of these characteristics and processes constitutes a basic requirement towards conceptualizing the uniqueness and complexity of child's personality. This need for a holistic and in depth understanding of child's personality has focalized *socio-cultural approaches* of learning and development in early childhood science education as well as early childhood science education research (Fleer & Robbins, 2003; Fleer, 2008; Fragkiadaki & Ravanis, 2016).

In this paper, a qualitative study on the conceptualization of dissolution of solids into liquids by 5 to 6 years old children within a socio-cultural activity framework is presented.

## 2. Theoretical Framework

Thus far, there has only been a minor amount of research studies regarding the comprehension of dissolution of solids in liquids by young children.

Piaget and Inhelder (1974) discovered that children from the age of 3 years old attribute characteristic properties of the solvent to the solution itself, claiming that the properties are carried within the matter. However, their research has exhibited that children aged 3 to 5 years old are not able to predict the conservation of the solute.

Rosen and Rosin (1993) have shown that preschool age children comprehend that the properties of an invisible solute will be transferred to the solution. However, they discovered that the children of the sample had a narrow comprehension of the conservation of mass phenomenon, as they recognize that the substance is segmented and continues to exist within the solution. Furthermore, another quite significant finding of this research was that regardless the children are familiarized with the solute or not, they recognize its presence into the solution.

Another relevant research focused on the recording and classification of 5 to 6 years old children's mental representations, while they are asked to predict issues concerning the dissolution of a solid substance in water or oil (Panagiotaki & Ravanis, 2014). The results showed that a significant part of the children does not detect differences between the dissolution of sugar in water or oil, that there are major differences when children use drawing while they are trying to predict the phenomenon and that although in their drawings children seem to comprehend the conservation of sugar in the solution, in their predictions many of them assume that sugar is not conserved.

On the subject of conservation of the solute during dissolution, Holding's (1987) research indicates that initially, a percentage of students, understands the preservation of the substance, whether a smaller percentage only gets to the preservation of weight. This percentage steadily grows as the age of the children is increased. *"On this subject, Slone and Bokhurst (1992) studied 4-13 year old students' thinking and detected an instability, namely a fluctuation of the number of answers where, in that particular age scale, preservation is recognized, with a final reduction of the percentage in 12-13 years old"* (Panagiotaki & Ravanis, 2014, p. 580).

This research has been carried out within frameworks aiming either to record young children's representations, or to transform them. However, the importance of a *socio-cultural approach* for children's development has been increasingly highlighted in recent years. Using qualitative research approaches, according to a socio-cultural perspective the dynamic and complex interrelations between people (children and/or

adults), the social as well as the cultural context along with child's intellect, affect and act in different settings is emphasized. Furthermore, the mediating role of material objects, signs and tools found in cultural and social settings is highlighted. Instead of following the classical research methods and techniques, focused on limiting and correlating variables, in a socio-cultural framework studying and composite relationships between variables is dominant. This conceptualization constitutes the key idea of the *socio-cultural approach* (Hedegaard & Flear, 2008).

Thus, from a methodological perspective, a need for new research tools in order to study the dynamic educative processes was emerged. These methodological tools have been developed in order to fulfill the need for understand childhood in all its uniqueness and complexity (Robbins, 2005, 2009; Flear & March, 2009; Flear, 2011; Roth, Goulart & Plakitsi, 2013). Within this framework, the child's individual process of thinking, feeling and acting, and the interactions recorded through intersubjective forms of reasoning are dialectical interrelated and interpreted. Furthermore, the situational characteristics that arise from child's social and cultural reality and support development of children's thinking, understanding of the subject matter of discussion, using practices of object handling as well as conceptualizing potential or established analogies, metaphors or reductions to their familiar environment are highlighted. According to Fragkiadaki and Ravanis (2016, p. 311), a survey of these methodologies can reveal the dynamics of three integrated analytical schemes and interpreting models that constitute points of reference in the described view. These methodologies are: a) the 'three foci of analysis' multi-level method developed by Rogoff (1995, 1998); b) Hedegaard's model of approaching young children's learning and development (2008); and c) the use of the theoretical concept of *perezhivanie* as a methodological analytical tool introduced by Vygotsky (1994, 1998). However, apart from the use of systematic methodological tools and analytical concepts, within the broad spectrum of the *socio-cultural perspective*, concrete methods of organizing the research procedures are also raised. These practices aim at organizing the research procedure in a way that facilitates the study of dialectical interrelations between the child and his/hers environment. Play activity has been one of these dynamic methods. The significance of the children's play activity has been emphasized through many researches within the broader field of socio-cultural and cultural-historical educational and psychological research (Vygotsky, 1966; Elkonin, 1999, 2005; Flear, 2009, 2010; Van Oers, 2010), while it has also constituted the methodological framework for the organization of research processes in that field (Ferholt, 2010; Flear, 2011, 2013).

Regarding to the above theoretical and methodological standpoint, the present study attempted to approach issues related to the conceptualization of solid in water

dissolution by 5 to 6 years old children. Thus, the following research questions are posed:

- 1) How do young children conceptualize dissolution while participating in an interactive play activity in kindergarten?
- 2) In what way children's experiences and social interactions during play facilitate the transition of reasoning constructed during the exploration of one natural system (water-salt) to another natural system (water-sugar)?
- 3) Is it possible for young children to develop methodological skills for the distinction between soluble and insoluble materials through an interactive play activity with natural elements?

### 3. The methodological framework

Four 5 to 6 years old children took part in the research procedure, playing in two different groups. The children were students of an urban area kindergarten class in Greece. During the research procedure, the researcher and the kindergarten teacher cooperated with the children as well as encouraged them to express their thinking and to maintain the continuity of their arguments (Adams, 2015).

The research procedure was based on the utilization of *conceptual play*. According to Fler (2011), *conceptual play* constitutes a form of educative activity that combines learning and playing. Within this framework, children participate and are motivated in play-based programs in which teachers are mediating through play between children's everyday concepts and children's scientific concepts formation. In the playful activities that occur within this framework, children spontaneously use signs, tools and objects and give them a specific and symbolic meaning. A dynamic situation is produced through merging imagination and reality within *conceptual playing*. Within this framework, children are able to conceptualize various concepts and phenomena of the natural world such as dissolution.

In the present study, the children of the sample were asked to play with a puppet named Ms. Cloclo, without any more instructions given to them. The scenario of the *conceptual play* was introduced to the children by a member of the research team. The scenario was about the need to prepare a hot beverage for Ms. Cloclo, who was supposed to be ill. The puppet was manipulated by the teacher.

Research procedure was carried out in three stages. In each stage, the researcher along with the teacher formed a different educative scenario that contextualized each activity.

1. In the first stage, the children were asked to prepare a soup for Ms. Cloclo because she was supposed to be ill. The children were encouraged to enter the classroom-dollhouse and experiment with various materials, such as sugar, salt, pepper, plastic models of food and water in order to cook the soup. The children were asked to consider as well as to describe the state of the materials when they were sunk into the water.
2. In the second stage, carried out a few days later, Ms. Cloclo was supposed to be still ill. The researcher suggested preparing herself a hot beverage. The puppet was supposed to refuse drinking the beverage. The children were encouraged by the researcher to explain the reason why she does not like it as long as no materials were visible into the beverage.
3. In the third stage, Ms. Cloclo asked the children to make her a different hot beverage because the first one made by the researcher was not to her liking. The researcher presented a white cooking dust (niseste flour) that constituted the base for preparation of the beverage. In this particular stage, the children were asked to predict what will happen to the cooking dust if it is mixed with water.

The three stages of the research procedure design aimed to provide an understandable and motivating framework for the children's play. This framework boosted children's engagement, and participation in the activity. The need to provide solutions for real life problems, such as the illness of a person closed to them needing help, engaged children's thinking on the natural phenomenon and enforced them to relate every day concepts and experiences from everyday life with scientific concepts and scientific activities (Rogoff, 1997, 1998). Furthermore, the researcher and the teacher encouraged the children to interact with each other as well as to refer to their sources of knowledge throughout the three stages. The conversations developed between the children, the researcher and the teacher were recorded while at the same time field notes were kept. A conversation analysis to the qualitative data collected during children's play followed.

#### **4. Results**

A qualitative analysis of three concrete excerpts from the conversations that were developed during the research procedure is following. Each excerpt provides evidences related to the three research questions.

### 1<sup>st</sup> Stage – 1<sup>st</sup> Research Question

During the first stage, there was constant interaction between the children themselves as well as with the researchers. The everyday sources of knowledge were emphasized through these conversations, and, regarding salt's solubility, we recorded strong confrontations between them, as well as changes in their thinking attributed to this framework of communication.

In following excerpt (Excerpt 1), we emphasize the processes through which children form and develop their reasoning concerning the natural phenomenon as they are involved dynamically in *conceptual play*. The discussion recorded was elaborated when the two children decided to "cook" a "shrimp soup" for the ill doll. While the two children were cooking the soup in the kindergarten's dollhouse, they put salt in two shrimps and then submerged one of them in the water symbolizing the soup. When the children withdrew the shrimp from the water, they noticed that the salt was no longer on it. The following conversation that was developed between the children and the researchers drew on this observation (Excerpt 1).

#### *Excerpt 1: Conceptualizing the dilution phenomenon while cooking an imaginary soup*

1. Researcher 1 (R1): *Is the salt visible (on the shrimp that came out of the water)? Why?*
2. Child B (B): *Because... (he is trying to think).*
3. Puppet (P): *How is this happening, I'll go mad!*
4. Child A (A): *Because it is more... It goes in and dissolves in water.*
5. R1: *Does it dissolve?*
6. B: *No. It doesn't dissolve.*
7. A: *Yes. It does! (emphatically)*
8. P: *Which thing?*
9. R1: *What do you mean?*
10. P: *Which thing dissolved?*
11. A: *The salt (loudly)!*
12. P: *How did this happen?*
13. B: *Oh well.*
14. A: *It happened because it is very transparent. Look.*
15. *[Non-relevant conversation]*
16. A: *It dissolves.*
17. R1: *Is the salt transparent from the beginning?*
18. A: *No.*
19. B: *No guys.*
20. R1: *What color is it in the beginning (towards A)?*

21. A: *Umm... white.*
22. R1: *And then it becomes transparent?*
23. A: *Yes, later it disappears.*
24. P: *How does this happen?*
25. A: *It just does.*
26. B: *Why? Because if you drop it, see? It goes away* (drops the salted shrimp in the water).
27. P: *How does this happen?*
28. A: *Look, look, look.*
29. R1: *Yees...*
30. A: *Look. Look, look, guys look* (Points towards the “soup” bowl, in which the salt cannot be seen).
31. R1 and P: *Yeeees...*
32. B: *I can see it* (has already taken the shrimp out of the water and holds it).
33. A: *It disappears.*

In this conversation the course of child B’s thinking is of particular interest. It appears that he approaches the phenomenon of dissolution for the first time drawing on the communication framework that is developed during the game. During the exchanges with child A and the researcher and the puppet, child B conceptualizes the phenomenon of dissolution. The claim that salt is visible in water [Excerpt (E) 1, Line (L) 32] signifies the understanding that salt exists in water. It is also of interest that while child A knew that salt will dissolve in water, due to their engagement in the play, the two children seek the cause of dissolution. Thus, they attribute the phenomenon to color, initially using a “convenient” explanation pattern: salt is transparent in and outside of the water (E1, L14). Consequently, however, within the framework of interaction they recognize that salt is white (E1, L21).

### **2<sup>nd</sup> Stage – 2<sup>nd</sup> Research Question**

During the 2<sup>nd</sup> stage, child B, while trying to help the puppet drink the beverage, refers to an experience from his everyday reality. He mentions that his mother adds sugar when she prepares strawberries for him and that is why his strawberries taste sweet although he cannot see the sugar. The researchers discuss with child B the ways in which it is possible for the strawberries to taste like sugar, but without anybody being able to actually see the sugar. The elements of the socio-cultural environment that facilitate the emergence of the issue of dissolution are emphasized in the conversation that occurs. In this stage, the subject of interest was whether child B, who discovered dissolution through salt and water, is able to expand his reasoning so as to encompass



the sugar-juice solution. In this case, however, this will not happen by a solute dissolving into water, but tracing a pre-existing solute already in the water.

*Excerpt 2: Referring to a corresponding experience from daily life*

1. R1: *So are you saying that your mum puts sugar on them and, while the sugar is white, afterwards you can't see it.*
2. P: *Yes, I can't see it either...*
3. R1: *Ooh.*
4. P: *I mean that I have seen plenty of times the strawberries in B's food, and he drinks the syrup afterwards. B drinks the syrup that is left over from the strawberries.*
5. R1: *Yes, I remember.*
6. P: *...But I didn't see any sugar.*
7. R1: *But did it taste sweet?*
8. P: *When you drink...*
9. B: *Sweet.*
10. R1: *Sweet?*
11. P: *How can it be sweet if I don't see any sugar in it?*
12. B: *It tastes sweet.*
13. P: *But how can something be sweet if I can't see sugar in it?*
14. B: *Because it's gone in the juice.*
15. P: *How is this possible? What has, what do you mean it has gone in it?*
16. R1: *Excuse me, do you mean to tell me that there is sugar but it's not visible?*
17. B: *Yes.*
18. R1: *Yees?*
19. P: *It has gone in? What do you mean it has gone in? This is quite something. But... How is it possible for sugar to go in the juice... and I can't see it?*
20. A: *I don't know.*
21. P: *Think...*
22. A: *I am thinking, but I can't.....*

In this conversation, child B is recalling an experience from his everyday domestic reality (E2, L1) and both the researcher and the puppet utilize this reference in order to help him conceptualize the idea of a dissolved but invisible substance. During this conversation, we observe the child having a stable view of the subject of dissolution, even though, as is expected, he cannot provide any interpretation of the phenomenon (E2, L20-22).

### **3<sup>rd</sup> Stage – 3<sup>rd</sup> Research Question**

The conversation regarding the use of familiar materials highlighted yet another potential of the socio-cultural educative framework. As children steadily gain consciousness of dissolution of known solid materials in known liquids, they also develop a methodological ability relating to possible ways to find out whether a solid substance dissolves in a liquid.

#### ***Excerpt 3: Suggesting the strategy of “trial and confirmation”***

1. P: *In order to know, let me ask you this, in order to know – every time though – if something can be seen or not.*
2. B: *We have to do it.*
3. R1: *Ooh!*
4. P: *We have to do it? What do you mean by saying do it?*
5. R1: *What did you say? Tell me so I can think.*
6. B: *We have to... to... to see it first.*
7. P: *What do you mean “to see it”?*
8. A: *It is narrow, small.*
9. P: *B, what do you mean by saying “to see it”?*
10. B: *To... to... to see first if it can be done and then do it as a view...*
11. P: *Mmhm ...*
12. R1: *Ohh...*
13. B: *.... And then see it and do it.*
14. P: *And after that what happens? You mean take a material...*
15. B: *Wait...*
16. P: *What will happen if we see it, if we do it? What you said. For example you want to see, um, I am giving you two materials, cinnamon and chickpeas.*
17. B: *Cinnamon and chickpeas!*
18. P: *What do you have to do?*
19. B: *We will be able to see them!*
20. P: *Do you think so?*
21. B: *Yes.*
22. P: *Good. What will you have to do, however, so you will be sure?*
23. B: *To... To see it first.*

This conversation emphasizes a methodological issue whose interest is extended beyond the category of children aged 5 to 6 years old. The problem of distinguishing a substance’s dissolubility in the level of basic education or, more generally, among

minors and adults without specified knowledge, is solved with the use of a “trial and confirmation” strategy. As it is observed, child B suggests the application of this strategy on materials whose dissolubility in water is uncertain (E3, L2-6, L10, L23). In this respect, it appears that this framework facilitates the orientation towards the development of a methodological ability.

## 5. Discussion

The conversation analysis of certain excerpts from these rich in interactions findings, highlighted the dynamics of young children engagement with *conceptual play* regarding the conceptualization of a natural phenomenon. The communication circumstances that were created, along with the mediating role of the adults, motivated the children emotionally. Therefore, children recollected experiences from their everyday life, which they adapted and processed. The highlighting of these elements seems to be promoted by the socio-cultural analysis used here. This choice illuminates both socio-cultural factors and processes of interpersonal communication, in parallel with the study of the children’s individual reasoning.

Thus, according to the data presented here, the example of sugar’s dissolution in the strawberry juice is a typical case of consecutive displacement from everyday life at home to *conceptual play* and vice versa. Furthermore, it is truly remarkable that this connection is realized with the dissolution of solid in liquid as a subject.

Furthermore, the methodological finding in Natural Sciences research field is equally important. The “pressing need” to concoct a beverage that satisfies the ill puppet poses the idea of the “test”, as it allows for the organization of experience common to minors and adults with no specialized knowledge.

Therefore, it appears that the socio-cultural environment urges children towards the development of reasoning and practices compatible with the scientific ones through procedures that utilize their experiences. These findings are in accordance with research data that, within the same theoretical and methodological framework, approach other scientific concepts such as clouds (Fragkiadaki & Ravanis, 2014, 2016). *Conceptual play* was of paramount importance in the development of the activities, as claimed by Fleer (2011). Children did indeed conceptualize the situation within the framework of “Ms. Cloclo’s illness”, but were grounded back to reality when they were required to explain their thinking on the dissolubility of substances. Play is part of children’s everyday life and its use aided them in processing their thinking.

The *socio-cultural approach* of phenomena and concepts of the Natural Sciences in young children explore a new perspective in Early Childhood Science Education: it

allows for the transition from merely seeking to base educative practices on children's social and cultural representations to recognizing that these exact representations can be the locus of knowledge itself. Towards this orientation, we can find a broad field for the development of research and applications.

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