Investigating Pre-School Children's Ability to Formulate Logical Arguments

Vasiliki Pournantzi, Konstantinos Zacharos, Maria Angela Shiakalli

***ABSTRACT**: This paper attempts to investigate five and six-year old children's ability to formulate logical reasoning. More specifically, our interest focuses on the investigation of young children's ability to use arguments based on logical reasoning. Can pre-school children build arguments based on logical reasoning such as deductive reasoning, or forms of indirect reasoning? Can teaching contribute to the development of you children's ability to manipulate logical reasoning in the forms previously mentioned? These are the basic questions we attempt to answer in this paper.*

Thirteen pre-school children participated in the study. The children were involved in organized dialogues in order to investigate their ability to build logical argumentation. Our findings showed that the children had the ability to use arguments with structures, resembling reasoning found in formal logic such as deductive reasoning, inductive reasoning, as well as reasoning based on the law of excluded middle.

***Keywords**: pre-school, logical arguments, deductive reasoning, indirect reasoning*

INTRODUCTION

Can pre-school children use basic concepts encountered in the science of logic which consist of basic conditions for the development of scientific thought? The aim of this paper is to investigate young children's ability to use specific forms of justification which are found in the science of logic, such as, deductive reasoning, forms of indirect proof, cause-and-effect relationship, or arguments based on the inductive method.

Numerous meanings have been given to the concept of logic: it may be used with the concept of common sense or as the principles of predicate calculus, or as a mathematical subject, as well as a branch of philosophy. For the purposes of this study logic is defined as the science consisting of the semantic and syntactic aspects aiming at the formulation of conclusions which stem from a group of premises (Durand-Guerrier et al. 2012).

Arguments and justification often appear in our speech, especially when formulated in order to justify a conclusion. In other words, arguments are forms of justification or conclusion. In order to prove (or justify) a claim, we construct an argument, a group of sentences, with strict or looser structure, which lead to a conclusion.

One of the aims of institutionalized education is the gradual passing from informal forms of knowledge and the everyday use of language to the use of scientific language and, hence, to forms of arguments which are found in science.
Argumentation differs from everyday conversation as it is a more organized and systematic form of verbal communication (Daniel 2005).

Contemporary curricula, as early as pre-school, aim at the development of children's creative and critical thinking (Van de Walle 2007; Shiakalli, and Zacharos 2014; Zacharos et al. 2011). In recent decades a particulate research interest has developed in the area of teaching subjects relevant to and consisting of, reasoning which are based on the science of logic. There is also a growing interest for the introduction of school subjects defined as Philosophy for Children (Colom et al. 2014; Gasparatou, and Kampeza 2012; Lipman et al. 1980). This specific research and teaching interest, aims at developing children's ability to justify, as well as to raise their awareness concerning social and ethical issues. The above mentioned interest also extends to the correlating in- and pre-service teacher training, concerning the use of logical reasoning in education (Durand-Guerrier et al. 2012).

The assessment of research within the area of Philosophy for Children shows a positive contribution of the previously mentioned teaching interventions, in areas such as reading and mathematics, children's reasoning ability improvement, as well as improvement in teacher academic readiness (Colom et al. 2014).

Critical thinking development allows people to construct logical meaning, justify their thoughts with logical arguments and, thus, persuade others about their correctness. It also allows people to evaluate their own practices on the one hand, and agree or disagree with others' opinions justifying their choice, on the other. Thus critical thinking is, essentially, about the important aspects of the educational process that enhance the development of metacognitive thinking strategies and arm the student with the ability to reflect on the process of learning (Fisher 2007; Ergazaki et al. 2005). Moreover, it is about practices simulating the evidentiary procedures which are established in education, and more specifically in mathematics education, where elements, such as claim (the statement of the argument), data (data justifying a claim) and warrant (the inference rule allowing data to be linked to a claim), are found (Toulmin 1958. In Arzarello et al. 2009, p. 41).

The teacher's role is important in children's critical thinking development since it is he/she who is responsible for the creation of a learning environment, where formulation of claims, questions, controversies and synthetic reasoning, are allowed to thrive (Haynes 2008).

The study presented in this paper refers to forms of argument, which are found within the science of logic, and are accessible by educational practice. More specifically, we present forms of reasoning which, according to bibliography, can be comprehended, and used by, young children and thus, can become subjects of teaching. We then present our research questions and our investigative method. Lastly, we analyze and comment on our data and discuss our argumentation concerning the possibility of systematically engaging pre-school children in forms of reasoning.

THEORETICAL REMARKS

The Concept of Argument

Argumentation is a form of logical thinking, developed during the process of a person's cognitive development. It consists of an entity of isolated, though interrelated, propositions, each having a different degree of generality. Aristotle systematically attended to the forms of argument and his conducts comprise the basis for the development of the science formal logic.

In this paper, we deal with arguments in the form of deductive reasoning, as well as arguments based on indirect reasoning (Genesereth, and Kao 2013; Getmanova 1989). Arguments based on deductive reasoning, in their simplest form, consist of two premises and a conclusion. Thus, the structure of simple deductive reasoning is: all p are q (first premise); t is a constituent of p (second premise); therefore t is q (the conclusion).

A type of indirect reasoning, is reasoning which in formal logic is found as "modus tolens", and is based on the principle identified as "law of excluded middle". A verbal expression of this type of reasoning would be: if p is true, then q is true (first premise), but if q is not true (second premise) then p is not true either (conclusion). This type of reasoning is based on an internal structure, and the conclusion arises as a unique and unambiguous consequence of the two introductory statements (premises) of claims of the two premises. The relationship between premises and conclusion resembles the relationship between cause-and-effect. "The 'if' part explains the 'then' part" (Grabiner 2012, p. 163).

A person with highly developed theoretical thought perceives premises as a single logical system, from which the conclusion is implied. In these cases, the conclusion does not require personal experience; it is derived from the logical validity of the reasoning. Such forms of logical operations are basic forms of expression of human thought.

While the above mentioned logical schemata seem as basic properties of human logical thinking, according to the cultural-historical approach, the development of logical schemata is related to cultural factors (Luria 1976). Luria (1976) experimentally studied the above hypothesis and found that the ability to perceive the structure of reasoning as a single system is a result of social transfer. Respectively, in a study by Scribner (1977) the term «empirical bias» is used to state the tendency of some people living in traditional societies, to base their conclusions on everyday experiences instead of reasoning facts. This type of reasoning is characterized as "empirical", unlike reasoning which is based on the content of sentences (premises) and is characterized as "theoretical".

Children's Ability to Use Reasoning

According to J. Piaget (1956), up to the age of twelve, children cannot form complete reasoning, especially when the structuring data are hypothetical or conflicting to their experience. When young children are faced with a logical problem they adopt an empirical approach rather than a methodical theoretical model corresponding to the structure of the given reasoning.

According to Piaget (1953) children's ability to develop logical thinking and logical thinking understanding as well as the ability to formulate arguments, presupposes their familiarization with operational systems such as "the classification or the inclusion of classes under each other. For example, sparrows (A) < birds (B) < animals (C) < living beings (D)" (p. 13). Moreover, Piaget (1953, p.3) claims that young children find it difficult to reason about a whole and its parts at the same time, and that the ability of transitivity (for example, when A=B and B=C, then A=C) is absent from a child before the age of seven or eight. Operational systems, as those mentioned above, play an important role in the structuring of logical reasoning since "all effective knowledge is based on such a system of operations" (Piaget, 1953, p. 7). But, within Piaget's epistemological frame the development of reasoning is mainly a spontaneous aspect of intelligence rather than a matter of teaching (Piaget, 1973).

More recent, studies show that young children have a greater chance to succeed in tasks which are designed in a manner that triggers their interest (Donaldson, 1984). Other findings show that four and five year old children, demonstrate the ability to use deductive reasoning (Dias and Harris 1988; 1990; Richards and Sanderson 1999) and can evaluate the truth or untruth of a sentence, recalling arguments made in a previous time (Koenig et al. 2004). In fact, young children could respond to deductive reasoning even in the cases where the premises described imaginary situations inconsistent to their experiences. Often children's answers were justified, and based on, information given by the premises (Dias and Harris 1990; Dias et al. 2005). In a similar study by Richards and Sanderson (1999), pictures were introduced in order to help children with reasoning data memorisation. Their findings show that the use of pictures led to more correct answers.

To sum up, studies show that children, as young as pre-school, are able to distinguish between real and imaginary situations. Moreover, children accept the contracts described in imaginary situations, even in situations of counterfactual thinking, and accept the premise claim as a starting point for following the reasoning process (Harris 2001; Skolnick and Bloom 2006). Similarly, four and five-year old children succeeded in the case of inductive reasoning, where they were asked to think within situations contradicting reality (German and Nichols 2003). Difficulties were encountered when the chain of sentences constructing the reasoning process was long, thus making it difficult for the children to follow the sequence of events (Beck et al. 2006). It should be noted that all research to which we have referred above, was conducted within a framework which assisted children to accept the hypothetical situations and, thus, succeed in the reasoning process activities (Dias and Harris 1990; Richards and Sanderson 1999; Leevers and Harris 2000).

Other studies conducted in order to investigate the forms of argumentative verbal interaction between pre-school children, found that systematic occupation with such practices improved the quality of children's arguments (Daniel 2005; Gasparatou and Kampeza 2012). It was noted that children were able to substantially move from their personal experiences and egocentric approaches, towards the development of more complex thinking skills such as justification, constructive criticism of peer arguments, argument assessment and challenge. The development of such ability sheds light on the contribution of systematic teaching intervention within the sphere of the process of reasoning (Daniel 2005).

The Contribution of Verbal Interaction

Argumentation and reasoning process development, at the early stages of schooling, are solely based on the classroom forms of verbal interaction, since it is through such interaction that a common framework of meaning is established (Storm et al. 2001; Mercer 1995; Mercer and Wegerif 1999; Mercer and Sams 2006). Children are guided to co-operate in order to (a) help each other in creating and building arguments, (b) strengthen their opinions or accept different approaches, (c) focus on new aspects of knowledge. Of course children's participation in group activities does not necessarily ensure a meaningful involvement in the learning process (Mercer and Sams 2006), since this presupposes each team member's familiarization with the practices of team co-operation. It is here that teacher interventions are essential. Firstly, the teacher guides children through ways of communication development. Secondly, he/she is responsible for the the formulation of groups in a way that all members are able to contribute to the construction of meanings and, eventually, knowledge.

In analyzing the forms of verbal interaction, Mercer (1995), distinguished between three typological interactions: *(1) disputational talk*, which is characterized by participant conflict and disagreement and individual decision making, (2) *cumulative talk*, where members positively construct verbal communication without criticism of what has been said. In this way the construction of common knowledge is cumulated and is characterized by repetition, confirmation, and processed reformulations, (3) *exploratory talk*, which is considered the most productive type of talk, since members discuss each other's ideas critically but also with a positive attitude towards creating a synthesis of all ideas.

Research Questions

The research questions we set out to answer in the paper are:

- Can pre-school children use arguments based on logical reasoning such as deductive reasoning or forms of indirect reasoning?

- Can teaching contribute to the development of pre-school children's ability to use the above forms of logical reasoning?

The formulation of our research questions was based on the criteria that deductive and indirect reasoning are forms widely negotiated by the science of formal logic and are objects of research and teaching interest, as previously mentioned in this paper.

Methodology

Sample

This paper presents a case study (Cohen et al. 2007) carried out in April 2014 at a public pre-school setting in Greece. The sample consisted of thirteen children (referred to as S1-S13 in this paper) nine boys and four girls (aged 5,5 -mean) from middle class backgrounds. In Greece preschool

involves two years of schooling. All participants had attended at least one year of formal pre-school and were familiar with adult-child teaching interactions. None of the children had been involved in forms of reasoning processes or argumentation within the school context.

Research Design

The study consisted of five autonomous teaching interventions. In total, the researcher conducted eight meetings (one meeting per day) with the children, two preparatory meetings in order for the children to familiarize with the researcher, and one meeting during which the "rules" of the communicative framework were set. The aim of the third meeting was for the researcher to present the suggested "rules" of the communicative framework to the children, and for the children to agree to those terms in order for them to actively participate in the teaching intervention process (Fisher 2007; Haynes 2008). These "rules" consisted of: participating in the group discussion in an attentive and polite manner, speaking softly, and paying attention to the story read by the researcher, freely posing their opinion when asked. As mentioned in the bibliography, children participation in active listening is a matter of teaching and learning (Coles 1991).

The following five meetings were used for the teaching interventions. The paedagogical context for the introduction and investigation of the children's reasoning process, was formulated by the reading of a different story every day. The stories were chosen by the research group based on their adequacy to serve the teaching goal. Story adequacy was established through a pilot study. All storybooks were published in Greek - either original works in the Greek language or works translated into Greek. All stories were revised into autonomous brief articulated stories in order (a) to allow narration interruptions and (b) to facilitate the researcher to ignite children discussion.

Intervention duration varied, according to narration length and children's correspondence, from 25 to 40 minutes. Data were collected through recordings, children's representations and the researcher's field notes.

Data Analysis

For the purposes of the study, and based on our data, we used specific dialogue analysis typology and classification. Our data showed three types of argumentation children used in order to justify their answers:
We defined the first type as "non structured argumentation" consisting of the following characteristics:

- Simple sentences without argumentation ("just because", "I do not know", "Because I believe so") or idiosyncratic answers without argumentation support,

- sentences leading to no conclusion and, often, presented as a type of internal monologue,

- sentences showing that the child had not realized the cause-and-effect relation between situations,

- sentences showing that children could not use logical relations such as "if p, then q" nor could they argue on hypothetical reasoning,

- sentences showing that children did not realize deductive reasoning as a single logical system,

- sentences showing that children had not yet familiarized with types of inductive reasoning and did not lead to any generalizations.

The second type was identified as "semi-structured" argumentation consisting of the following characteristics:

- children rationalized their thoughts and tried to justify them in order to convince their fellow speaker, but their arguments were tautological, consisting of unfinished expressions which often did not express a specific meaning,

- children often used vocabulary linked to justification such as "because", "why",

- children justified their opinions without considering the answers given by their peers,

- instead of addressing their peers, children addressed the teacher/researcher during argumentation or when they disagreed with the child who had expressed the initial thought, asking for adult consent,

- the team did not come to a conclusion, since there was no effective verbal interaction nor a commonly accepted problem to solve,

- children created reasoning based on simple premises without coming to a conclusion,

- children could justify some of the hypothetical story situations and could step into the shoes of the story figures.

The third type was identified as "structured" argumentation consisting of the following characteristics:

- children justified their opinion and formulated suitable arguments in order to persuade,

- based on facts, children, created logical structures of reasoning which led to logical conclusions,

- children perceived cause-and-effect relations in situations and phenomena,

- children created justifications about hypothetical situations and thought about situations opposed to reality,

- children could generalize their thoughts following an inductive thinking pattern,

- children operated in a co-operative and consensual manner.

TEACHING INTERVENTIONS AND DATA ANALYSIS

In this section we present selective data deriving from three teaching interventions, emphasizing on parameters of teaching interest and having the possibility of respective teaching intervention development.

First Teaching Intervention

Paedagogical frame: the teaching intervention was based on a story (Dimitriadou 2009), edited by the research team for the needs of the study.

The story: "while walking in his garden a king saw a little girl sleeping on the lawn. He was impressed and sat next to her, staring without waking her. The next day he anxiously waited for his daily walk in the garden hoping to see her again. He found her sleeping under a tree. The king sat next to her staring at her and when it was time for him to leave, he put a top next to her. The next day the king had to decide about starting a war, which his consultants believed had to be carried out. When he saw his generals planning the war he interrupted them and said "we are not having this war! No child will be ever happy if we go to war". And saying this he turned around and left".

Justification forms

i. Cause-and-effect

At this point the children were asked to answer the researcher's questions "why did the king decide not to start the war?" and "Is war a good thing?"

Children's answers often had the form of structured justification. Moreover, children often resorted to the introductory use of justification words such as "because", "for the reason that". In the first crosstalk children justified their thoughts and formulated arguments, in order to persuade of its correctness.

Crosstalk 1. Structured justification examples.

1.1 1.2	*T (Teacher)*: Why do you think that the king decided not to go ahead with this war?
1.3	S_4 *(Subject 4)*: because children do not like war.
1.4	*T*: Okey.
1.5	S_2: Because he is scared the little girl might be killed. […]
1.6	S_2: Or with all the noise made by war she might wake up. […]
1.7 1.8	S_5: Because if there was war the little girl might be killed and if she was killed the king would be sad.

	[…]
1.9	*T*: Is war a good thing?
1.10	*Students*: No!
1.11	*T*: Why?
1.12	S_3: Because people get killed.
1.13	S_{12}: A bullet might hit the little girl.
1.14	S_4: Maybe a grenade.
1.15	S_2: The little girl might not be wakened nor killed because the war will be outside
1.16	the kingdom.
1.17	*T*: Outside the kingdom. And what about the little girl?
1.18	S_2: She is inside, she is protected. They will be fighting outside the garden and
1.19	the little girl will be inside
1.20	S_3: Or she might lock so that they cannot come in.
1.21	*T*: The enemies are not able to come in?
1.22	S_3: Yes, they might have locked. The door that is. . . the garden door and the
1.23	kingdom door so that they cannot come in.

In the above crosstalk there are dialogues showing the children's ability to formulate justified reasoning about possible reasons for cancelling war. Lines 1.3, 1.5, 1.6, 1.7 and 1.8 show the way children formulate their arguments giving reasons for the king to cancel the war. Moreover, children justified, from an ethical point of view, the reasons for their belief that war is not a good idea (lines 1.12 και 1.13). Lastly, an alternative scenario was given for the cause of war postponement (lines 1.15 and 1.16- S2) and forms of structured justification were built on this possibility (lines 1.18, 1.19, 1.22 and 1.23).

Concerning the forms of verbal interaction (Mercer 1995) in crosstalk 1 there was intense of cumulative talk since each child participated in the conversation adding his/her opinion (lines 1.3-1.8, 1.12-1.15, 1.20) and expressing his/her own arguments (lines 1.15-1.16, 1.18-1.19, 1.20 and 1.22-1.23). Of course the talk observed in this Crosstalk did not lead to collective meaning construction since every member simply expressed their own argument independently.

ii. *Indirect reasoning development*

In crosstalk 2 the researcher set the question «Why did the king not wake up the little girl?"

Crosstalk 2. Hypothetical situation reasoning development.

A child (S13) claimed that the little girl probably fainted; another child (S2) opposed:

2.1	S_2: But if she had fainted how could she have got the top?
2.2	S_{13}: Or she might have been pretending to be asleep.
2.3	*T*: But then why did the king not wake her to ask what she was doing there?
2.4	S_{13}: He could have stayed at the palace for a long time and watched, that the girl
2.5	that the girl saw the king and then she went and then she went back to sleep
2.6	again.

On line 2.1 of the above crosstalk, a well structured argument was formulated by the child in order to answer the question. The cause-and-effect relation was highly processed and apparent. There was also a latent indirect reasoning which in the classical two-valued logic is called the "reductio ad absurdum rule" (also called the rule of introduction of negation). This type of indirect reasoning shows that judgment *p* should be negated (considered false) if a contradiction derives from *p* (Getmanova 1989). In the case of crosstalk 2, S2's claim that the little girl had fainted was confuted ("but. . . how could she have got the top?") leading to the denial of the first claim by S2. The justification attempt on lines 2.4 and 2.5 could not be considered sufficient, since its content was unclear and, of course, the cause-and-effect relation was not apparent.

Concerning verbal interaction at the beginning of the crosstalk, there was an alternation of disputational talk (lines 2.1 and 2.3) and cumulative talk (line 2.2). It seemed that disputational talk gave S13 the chance to formulate a well structured argumentation on the given question (line 2.2). Through disputational talk S2 also showed a clear formulation of a cause-and-effect relation on line 2.1.

iii. *Forms of deductive reasoning*

In the following crosstalk (crosstalk 3) through S4's justification (lines 3.5 and 3.7) a typical form of deductive reasoning could be detected: a general claim was expressed "all people love children" (first premise), which was specialized for a specific case "the king is a person" (second premise) followed by a conclusion "the king loves children".

Crosstalk 3. An example of deductive reasoning.

3.1	*T*: After nine months the little girl woke up and told the King it was time for her to
3.2	go home and that he should not be sad because he might find another child in his
3.3	garden.
3.4	S_3: But what will happen if he finds another child?
3.5	S_4: He will love it!
3.6	*T*: He will love it. Why do you say this?
3.7	S_4: Because all people love children!
3.8	*T*: Should the king be sad about the little girl's leaving?
3.9	S_3: No! Because he might see her again or he might find another child.

As in crosstalk 2 initial disputational talk (line 3.4) acted as a trigger, giving children (S3 and S4) the chance to express their thoughts formulating structured argumentation, in order to answer the question set by the researcher. The dialogues between researcher and children (S3 and S4) involving both, disputational talk and cumulative talk, gave an answer to the question set initially by S3.

Second Teaching Intervention

Law of excluded middle and inductive reasoning

The dialogues in crosstalk 4 highlighted children's ability to develop forms of argumentation based on variations of modus tolens reasoning (table 1). Of course, this form of reasoning was incomplete since the second premise was based on incomplete inductive reasoning, where the concept of the "middle term" did not consist of all possible cases.

Table 1. Forms of modus tolens reasoning

	Reasoning structure
1st premise	If statement p is true then statements q_1, q_2, q_3, ... are also true.
2nd premise	But statements q_1, q_2, q_3, ... are not true.
Conclusion	Then p is also no true.

Paedagogical frame: the teaching intervention was based on the story "Shovel on Mars" (translation from Greek) (Trivizas 2013), edited by the research team for the needs of the study.

The story: «Once upon a time, three astronauts went to explore Mars. When they finished exploring the planet they decided to go back to Earth. They collected all their things and left. But they forgot to take their shovel. When the astronauts left, the aliens on Mars, called Marsians, walked around the strange object they had never seen before and kept asking one another "what is this thing?". After long talks and hard thought they decided that it was a lamp post" (picture 1).

Picture 1. The shovel and the lamp post

In crosstalk 4 children used modus tolens reasoning (lines 4.1-4.6) while lines 4.8-4.13 showed the formulation of inductive reasoning justifying why the specific objet could be a lamp post.

Crosstalk 4. Modus tolens reason and inductive reasoning

4.1	*T*: if this was a lamp post (shows the shovel) would it have something special?
4.2	S_2 and *S3*: Light.
4.3	*T*: Light. But is this (shows the shovel) a lamp post?
4.4	*Students*: No!
4.5	*T*: Why?
4.6	S_4: Because it has no light. And it does not look like that.
4.7	*T*: How so? Can you explain?
4.8	S_4: It has no light, it has nothing to switch off.
4.9	S_{13}: Because it has no wood at the top and no metal at the bottom to dig. […]
4.10	S_{11}: Because it has no lamp. […]
4.11	S_9: Because it has no electricity. […]
4.12	S_6: It has no cord. […]
4.13	S_4: It has no switch to turn on.

Story continuation: "The Marsians continue looking at the strange object trying to find out what it is. "Might it be a lion?", said A Marsian. "Yes, yes it is", said another Marsian. "Just a moment! It does not look like a lion to me", said a third Marsian" (picture 2).

Picture 2. The shovel and the lion.

Similarly to crosstalk 4, in crosstalk 5 children based their justification on a modus tolens form of reasoning (table 1).

Crosstalk 5. Modus tolens reasoning.

5.1	*T*: If this (shows the shovel) was a lion, would it have something special?
5.2	S_4: It would have a tail.
	[…]
5.3	S_2: It would have a mane and sharp teeth and it would eat them up.

	[…]
5.4	S_{13}: It would have eyes and sharp nails and a tongue.
5.5	*T*: Good! So has this (shows the shovel) got sharp teeth to chew?
5.6	*Students*: No!
5.7	*T*: Why?
5.8	S_4: Because it is not a lion. It is a shovel.

Story continuation: "The Marsians continue to look at the strange object with the same curiosity. "Could it be a sponge?", said a Marsian. "Yes, Yes. It is a sponge", said another Marsian. "It does not look like a sponge to me", said a third Marsian".

Once again in the crosstalk following the storytelling, children formulated argumentations based on the properties of a sponge not found in a shovel. In their argumentation there was a modus tolens reasoning based on the law of excluded middle, where an option was accepted through the exclusion of other alternative options.

Crosstalk 6. Shovel and sponge comparison.

6.1	*T*: Can this (show the shovel) be a sponge?
6.2	*Students*: No!
6.3	*T*: Can it not be a sponge?
6.4	S_{12}: Because if you squeeze it you will not get any soap and water.
6.5	S_5: And it is not square with soap and water and soft either.

Overall, in the second activity, children developed forms of structured and semi-structured argumentation. Of course, there were instances of idiosyncratic answers, where children gave answers without justification or relativity to the questions and the subject of negotiation.

In crosstalks 4, 5 and 6 cumulative talk was evident. In crosstalk 4, the development of cumulative talk seemed to lead to a more complete determination of the characteristics of a lamp post. Interestingly, each child, participating in the discussion, added another characteristic, relevant to the characteristics already reported (lines 4.10-4.13). Similarly, in crosstalk 6, the children's participation in cumulative talk (S5 and S12) allowed them to formulate a more comprehensive reasoning process (lines 6.4-6.5).

Third Teaching Intervention. Argumentation Development

i. Joint arguments

Paedagogical frame: the original story was a variation of "Snow White and the seven dwarves" (Mantouvalou 2005), edited by the research team for the needs of the study. The story: "Far in the woods seven dwarves built their home. One day Snow White visited and stayed with them. The seven dwarves were very happy to have her. Every night after supper they would all play their favorite

question game. Snow White asked the questions and the dwarves answered. Tonight, Snow White started with a question for Wise Dwarf: "Why are you so self-centered?", asked Snow White. "Because I know everything and I can do everything on my own and I am very proud of this! I do not need anyone's help!", said Wise Dwarf proudly. "Yes" Snow White replied "but you cannot say that you do not need anyone's help for anything, because there are things you can do only with the help of others".

At this point the researcher asked the children what they thought on one's bragging about doing everything on his own. The children presented their arguments about the necessity of ethical values such as co-operation, arrogance, and self-centeredness. Crosstalk 7 (especially lines 7.5-7.9) showed the way children joined their ideas building an argumentation for the necessity of co-operation and the avoidance of arrogance.

Crosstalk 7. Joint argumentation.

7.1	*T*: I have a question for you. Do we need to brag that we can do everything on our
7.2	own?
7.3	S_3: No!
7.4	*T*: Why not?
7.5	S_3: Because someone might tell us something very difficult and we may not be
7.6	able to find the answer, others may have found it!
7.7	S_4: It may be a very difficult question.
7.8	S_5: One may not know something but others may know it and they will have to
7.9	tell him.

ii. The contribution of verbal interaction

Children's participation in the dialogues was a basic condition for the development of the teaching interventions. Children's participation was not symmetrical, since each subject participated differently (spoke more or spoke less or did not speak at all during conversations). Moreover, dialogue quality differed from child to child, since there were subjects who justified their thoughts with verbal completeness and structured justification, while others used vague verbal wording and idiosyncratic answers, characterized by the absence of justification. For example, in crosstalk 8 (lines 8.1-8.3) S2 used a form of verbal wording characterized by identitarian-cyclic speech. But with the researcher's intervention the child (S2), started gradually presenting indications of structured justification leading to significant improvement (lines 8.13-8.16).

Crosstalk 8. The contribution of verbal interaction.

For the first time during this intervention, S2 showed its intention to participate in the conversation and answered the question- whether we are able to do everything on our own without help from others.

8.1	S_2**:** And for only him to know, while others know and then if he thinks they do not
8.2	know anything he will think they are brainless and they might not know anything.
8.3	[…]
8.4	*T*: Should someone pretend to be wise, pretending to know everything?
8.5	S_2: No!
8.6	*T*: Why?
8.7	S_2: Because he thinks that others are brainless.
8.8	*T*: Okay.
8.9	S_2: Because it is not nice to tease others, it is like. . . us showing that we are wiser
8.10	than them.
8.11	*T*: But what if we know everything, why should we not brag about knowing
8.12	everything?
8.13	S_2: We can say it in another way, so that our friends get to know what we know. We
8.14	can say it politely, so that our friends can also learn a few things we know, but one's
8.15	friend cannot know what another knows that is why the other should tell him politely
8.16	so that he too can know.

Commenting on the children's general participation in this activity, we could say that: in most cases children's argumentation could be characterized as unstructured and only in a few cases could it be characterized as semi- structured. Children's responses were often single-worded while in other instances they would simply reply "I do not know". The arguments presented by the children were drawn from their everyday experiences and had limited "strength"; they were constructed jointly without any element of generalisation. Moreover, the children did not occupy themselves in the process of confuting ideas different to their claims; each child seemed to have their own opinion.

DISCUSSIONS AND CONCLUSIONS

This paper is a part of a broader research and teaching orientation, interested in the investigation of children's critical thinking development and more specifically the development of their ability to follow and use logical reasoning processes. This study dealt with types of argumentation which, within the frame of typical logic, are characterized as reasoning processes. We also looked at (a) types of argumentation which had the form of inductive reasoning and (b) children's ability to create cause-effect relations.

Our findings showed compatibility with current concern about the possibility of introducing teaching practices, in order to increase pre-school children's critical thinking within a paedagogical context guiding the use of logical reasoning (Dias and Harris 1998; 1990; Richards and Sanderson 1999; German and Nichols 2003; Dias et al. 2005).

Concerning our first research question, investigating pre-school children's ability to use logical reasoning processes mentioned in this paper, we found participants' responses to be satisfactory. Our findings showed that participants were able to (a) respond to the argumentation forms required in the first activity (crosstalk 1) , (b) use argumentation forms based on the law of excluded middle (crosstalks 2, 4, 5 and 6) and deductive reasoning (crosstalk 2), (c) use the form of inductive reasoning (crosstalk 4).

Not only did the children use the given information in order to come to the correct conclusion, but they also seemed to have accepted the commitments required by the activity communication frameworks, referring to situations contradicting their experiences. Moreover, they could develop argumentation on hypothetical situations. The above observations were in agreement with other research findings (Riggs et al. 1998; Leevers and Harris 1999; Beck et al. 2006) showing children's ability to cognitively decentralize from their immediate experiences, as well as their ability to build reasoning processes based on imaginary or hypothetical situations.

In the third activity children's argumentation was built on a collective process (crosstalk 7).

In the teaching interventions presented here, all forms of argumentation noted by bibliography were present (structured, semi-structured, unstructured). Strong structured and semi-structured argumentation was found in the first two teaching interventions and unstructured argumentation was encountered in the third teaching intervention (table 2).

This study was not based on a complete teaching proposal it was rather a detection of the possibilities for the development of a teaching intervention programme. Taking this into consideration, while attempting to answer the second research question, we could suggest the positive effects of a possibility of teaching such concepts in pre-school. Indeed, the communication framework within which such concepts were integrated seemed to stimulate children's interest and determine their positive emotional attitude towards the specific aims. Here, the communication framework's significant parameters were the verbal interactions between children and adult.

As noted by Mercer (2004), the use of language is the means for creating meaning between teacher and student. Guiding students, through suitable questions, is critical in children's familiarization with reasoning processes. This statement refers to the interweaving of concepts such as 'scaffolding' (Bruner 1978) and "the zone of proximal development" (Vygotsky 1978), a fact occurring in research which focuses on teaching and learning (Fernández et al. 2001). According to Bruner (1978) 'scaffolding' is described as cognitive support given by teachers to students to help them solve tasks they would not be able to solve working on their own. This statement closely relates the concept of "scaffolding" to Vygotsky's concept of "the zone of proximal development".

Based on our data, we could conclude that children basically resorted to cumulative talk, much less to disputational talk and not at all to exploratory talk (table 2). It seemed to be easier for the children to add their ideas to what had already been said, rather than to dispute or explore the ideas of others. This could be contributed to the following reasons: firstly, to the absence of a set of "ground rules" (Mercer and Sams, 2006, p.513) which would help children to familiarize with the development of a similar type of dialogue. Secondly the children had never before been exposed to structured mathematical reasoning activities. None the less, cumulative talk which was detected in certain instances gave (a) some children the opportunity to formulate their opinion more comprehensively and more clearly (crosstalks 2 and 3) and, (b) the possibility for a reasoning process to be completed with the participation of more than one child (crosstalks 4, 5, 6 and 7).

The above ascertainments were evident in all crosstalks presented in this paper, even in the cases where children's responses, within the dialogue, were not particularly productive (crosstalks 1 and 8).

Table 2. Forms of verbal interaction and forms of argumentation found in the study.

Forms of Argumentation	Semi-Structured	√	**Forms of Verbal Interaction**	Cumulative Talk √
	Structured	√		Disputational Talk √
	Unstructured	√		Exploratory Talk -

(√) : Forms observed during the study, (-): Forms not observed during the study.

Another dimension of the introduction of logical reasoning through children's literature is that (a) it leads to children's familiarization with the transfer process from free natural talk to the standardized language of logic and mathematics; a particularly important skill for the future stages in education (Durand-Guerrier et al. 2012) and, (b) it contributes to familiarization with forms of proof which are mainly found in mathematics education (Arzarello et al. 2009).

The fact that this was the first time, within the classroom context, that children had come into contact with such cognitively demanding processes and managed to respond sufficiently, showed the possibility of introducing such concepts in pre-school education. We believe that such teaching interventions can infiltrate across multiple disciplines such as mathematics, science education, linguistic education and philosophy for children. Of course succeeding in the implementation of programmes on the systematic introduction of reasoning processes in young ages, requires corresponding teacher preparation and encouragement (Gazzard 2012; Colom et al. 2014; Haynes 2008; Lipman et al. 1980).

Of course it is important to note that according to Bruner (1986), there is an important differentiation between a well-formulated logical argument and thought which is created by a narrative frame (such as the frames used in the teaching interactions presented in this paper). Although both can be used as means of persuasion, the former demands resourcing in typical or empirical proof processes, while the latter is based on the verisimilitude it offers rather than truth. During the reading or listening of a story, readers or listeners develop rhetoric in order to bring the object of narration to life. This strategy gives their reasoning a more specific form whereas expressions such as "if x then y" are characterized by their universality.

Concluding the presentation of this study, we need to note its restrictions having to do, mainly, with its small sample and pilot character. The former limitation does not permit us to generalize our findings, while the latter does not permit us to follow the children's cognitive development through the implementation of a long-term programme. Such an implementation would lead us to draw information concerning children's ability to respond to specific reasoning forms. Indeed, we believe that the research project presented in this paper highlights the need for

systematically studying forms of verbal interaction, especially the systematic recording of questions enabling the accomplishment of our goal: young children's familiarization with forms of logical reasoning.

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Address correspondences to:

1. **Vasiliki Pournantzi:** Pre-school teacher, Greece, vickypou1@gmail.com
2. **Konstantinos Zacharos:**
   Associate Professor, Department of Educational Sciences and Early Childhood Education University of Patras, Greece, zacharos@upatras.gr
3. **Maria Angela Shiakalli:** PhD pre-school teacher, Cyprus
   angelashiakalli@primehome.com