‘Early-years teaching of Science in Cyprus: Appreciation of Young Children’s Preconceptions

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List of Terms

1: Concept: The term 'concept' is used throughout the thesis to refer to all the different ideas that children might have about science. This term includes the correct as well as the wrong ideas.

2: Preconception: This term is used throughout the thesis to refer those ideas that children have about science which do not agree with those generally accepted by the scientific community. In other words we could say that the term 'preconception' will be used when referring to children's initial ideas. This term though is only used for children aged up to seven (7) years old assuming that children of this age have experienced limited or no exposure to science teaching.

3: Alternative Concepts: This term is used throughout the thesis to refer to those ideas that children have about science which do not agree with those generally accepted by the scientific community. However, this term, in contrast to preconceptions, will be only used for children older than seven (7) years old and adults, assuming that this group of learners (children older than 7 years old and adults) have experienced several exposures to science teaching.

4: Misconceptions: This term is used to describe incorrect ideas that learners establish about scientific ideas after being taught those areas. This term was not used throughout the thesis; it was replaced with the term ‘alternative concepts’ to avoid connecting children’s ideas with the negative connotation that this term has.

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2. Abstract

The goal of this study is to investigate the area of young children's preconceptions in science. The research focuses on teachers working in public and private kindergartens, and children attending these kindergartens, aged from three to five and a half years old. The area of the children's preconceptions, has been extensively investigated by other researchers in the past but research focusing on early-years teachers and children's preconceptions is still almost untouched, especially when talking about Cyprus. Inspired mostly by other countries' literature and the importance of foreign research results, this study aims at identifying the Cypriot teachers' appreciation of the children's preconceptions by discovering whether teachers identify and take into account the children's preconceptions when planning and teaching a Natural Sciences lesson. It also aims at giving suggestions and implications on how teachers can respond to the preconceptions that children might have. To do this, a case study has been applied to facilitate the utilization of a number of different methods, like questionnaires, interviews, focus groups, observations and a minor document analysis. The results indicate that teachers tend to avoid identifying the children's preconceptions when teaching Natural Sciences. This indicates that there is lack of appreciation of the children's preconceptions and their consequences when not acknowledged. It also indicates that teachers in Cyprus are not aware of the constructivist theory and its importance in children's learning. As a result, teachers in Cyprus need to be better trained and informed in regard to the children's preconceptions and to Natural Sciences in general. To help teachers respond to the children's preconceptions, the study develops a list of children's common preconceptions and a number of different ideas and suggestions for proper methods which can be used to help teachers identify the children's preconceptions and guide children to overcoming them.

3. Introduction

It is no longer necessary to argue about whether or not children already have some knowledge and scientific concepts, before entering formal education, which will affect their school learning of science (Black & Lucas, 1993). It is generally accepted that children do not come to school as a "tabula rasa", which means that they do not arrive to teachers as empty books waiting from them to fill them in with information (Pine, Messer & John, 2001). The same happens with the subject of Natural Sciences[1]. The science education community generally accepts the idea that students enter the classroom with their own understanding of the world (Henriques, 2002).

Some of the children's everyday activities enable them to learn some science even before entering pre-school education (Bradley, 1996). The difference is made when the child attends kindergarten for the first time, where he meets science as organised knowledge instead of unstructured and random activities that can happen outside school. Thus, it can be acceptable to start from the premises where each child has established different concepts which are often inconsistently applied and, most importantly, which are remarkably resistant to change (Black & Lucas, 1993). Therefore, investigating the children's preconceptions is necessary as it may provide guidance for future and in-service teachers on response to the children's initial concepts.

This research is part of the sustained effort to better understand the nature of educational phenomena. Hitchcock and Hughes stated that research is the collection and analysis of information that will help to understand and explain the

[1] Science for early years' in Cyprus is labelled and known as 'Natural Sciences'. For that, each time that reference will be made to early years' science the term 'Natural Sciences' will be used instead of 'science'.

world better. Research refers to the process of collecting and analysing data and information and it usually derives from an inquiry that is characterised by sets of principles and guidelines for procedures, and any research is subject to evaluation in terms of criteria such as validity, reliability and representativeness. Gregory (2003) defined research as: a) the action or an instance of searching carefully for a specific thing or person, b) an investigation undertaken to discover facts and reach new conclusions by the critical study of a subject or by a course of scientific inquiry and c) the systematic investigation into a study of materials or sources to establish facts and collect information

The guiding philosophy involved in this research and which will define the basic characteristics of this research was chosen by me – the researcher- as the most suitable. This research is expected to provide useful information and guidance to teachers and policy makers. Despite the huge number of educational research conducted over the past decades, “there are few areas which have yielded a corpus of research evidence regarded as scientifically sound and as a worthwhile resource to guide professional action” (Psillos et al, 2003, p4).

The choice of methods is not simple for researchers who usually choose their research methods based on their own viewpoints and beliefs about the nature of knowledge (Avramidis & Smith, 1999). This research is based on constructivism which refers to the belief that knowledge is constructed and that learners (including children) connect older concepts to new ones in a way that will help them understand what they are taught. As a result, the methods used for this research were carefully selected so that they would be appropriate for investigating the subject of interest.

4. Literature Review

4. 1. The context for the research

As this study is specifically interested in Cypriot teachers' appreciation of young children's preconceptions in Natural Sciences, it is considered necessary to make a reference specifically to Cyprus at first and then to Cyprus' educational system and National Curriculum. The long continuity of historical and cultural tradition interacts with recent political and economic commitments in regard to its recent entrance to the European Union (Zembylas, 2002). According to Zembylas (2002), Cyprus can be considered as a developing post-colonial country that struggles to discover a balance between local traditions and global influences.

Cyprus has always had an adventurous history, mainly because of its geographical position - at the juncture of three continents - which indirectly affected the current situation with education in Cyprus. More precisely, over the past five centuries, Cyprus was conquered by the Ottomans (1571- 1870) and then passed to the British Empire which ruled until 1960, when it was declared an independent republic (Papadakis, 2008). The solution of independence failed to satisfy the expectations of the Greek majority of the island demanding union with the cultural motherland, Greece. In 1974, Turkey invaded the island and occupied approximately 40% of the total territory of the Republic.

All the above along with the consequences of the Turkish invasion influenced every part of life in Cyprus, especially economy, the education system, and the society. After the Turkish invasion in Cyprus, the old Greek-Cypriot ideal for political union with Greece collapsed. In 1990, Cyprus applied to become a European Union member and declared the European orientations of its formal education. In 2004, Cyprus entered the European Union and this development along with the globalisation on both economic and cultural levels created new needs to modernise science education in Cyprus (Zembylas, 2002).

Since 2010, the school year in Cyprus is divided into two terms; each term lasts for four months and includes several holidays for religious and cultural occasions. The first term starts in September and ends in January. Then, children have a four-day break. The second term starts just in February and ends in May. After that, the children have to prepare for their exams which end by the end of May / beginning of June. Early-year and primary school children do not have any exams and finish school at the beginning of June. Since temperatures are very high during summer, the break lasts almost three months as it would not be practical for children to attend classes during the summer (Cyprus life education, 2007- 2011).

In Cyprus there are four hundred and eighty eight (488) registered pre-primary schools (325 public and 162 private) and eight hundred and twenty two (822) pre-primary classes for children aged between three (3) to five and a half (5,5) years (sigmalive, 2012). The school day begins fairly early, at 7.30am for secondary schools and at 7:45am for kindergarten and primary schools, and ends at lunchtime, at 1.05pm for kindergarten and primary schools and at 1:35pm for secondary schools. During the day, children have three breaks during which they can play outside and have their snack. In class, the children are not grouped based on their abilities like in the U.K. They work at the same level. If they do not achieve the expected grades through the year, they may be kept back to repeat a class with younger children. This is rarer for kindergarten and primary level children but it happens more often in secondary level (Cyprus life education, 2007- 2011).

It is also worth mentioning that the University of Cyprus was established in 1989, and before that the Pedagogical Academy of the Ministry of Education was the only institute which trained kindergarten and primary school teachers. To be able to study for free at the university of Cyprus students need to be accepted, after success at competitive entrance examinations at national level. Another option would be to study at one of the private universities in Cyprus or study abroad (e.g. Greece or Britain). The teacher training qualification is a four (4) year course and teachers are required to complete two (2) modules in regard to Natural Sciences. Qualified teachers that would like to work at a public school in Cyprus have to visit the Ministry of Education in Cyprus and register on a catalogue. At the moment there are two thousand and six hundred teachers on the specific catalogue waiting for their 'turn' to work in a pre-primary school within the public sector. Teachers might have to wait more than fifteen (15) years before they are given the opportunity to teach at a public school. Of course those teachers who want are free to find a teaching job at a private pre-primary school teach in these environment.

Finally, certain characteristics of the Cyprus climate may affect the children's experiences which are relevant to Natural Sciences, especially in regard to the 'Water Cycle'. Cyprus has a Subtropical climate - Mediterranean type, with very mild winters and warm to hot summers. Snow is possible only on the Troodos Mountains in the central part of the island. Rain occurs mainly in winter, with summer being generally dry. The data collection took place during

December, which is considered to be a rainy season in Cyprus. Thus, the context of the interviews and the lessons were not irrelevant with the children's everyday experience at that period of time.

The hot climate and the continuous drought of the last two years have confronted Cyprus with the problem of water shortage. Cyprus faces serious problems of water shortage and this leads to the need of raising the public awareness and asking for their collaboration. Media is the main means used to inform the public and it is likely that the children have, to some extent, been informed about the particular matter. Teachers are free to use any handbooks, teaching materials and resources that they find useful. Their main reference when planning and teaching a Natural Sciences lesson though seems to be a reference book which was published in 2004 by the Ministry of Education (title: Natural Science in the Kindergarten – A reference book for the Early-years Teacher). The specific reference book includes examples of Natural Sciences lessons and is available to all pre-primary teachers (Nicolaou & Kiriakidou, 2004).

4. 1. 1. Educational System in Cyprus

In his reports, Solsten (1991) identifies that the educational system in Cyprus consists of pre-primary and primary schools, secondary general and secondary technical/vocational schools, and special schools for the blind, deaf, and other teachable handicapped persons. In addition, there were institutions for teacher training, specialised instruction, and informal education. Until the early 1990s, when the first university in the Republic of Cyprus was established, undergraduate studies in subjects other than the ones taught in Cyprus institutions had to be pursued abroad.

The constitution of 1960 assigned responsibility for education to the Greek Cypriot and Turkish Cypriot communal chambers. After withdrawal of the Turkish Cypriots from all state institutions, the government proceeded with the establishment of the Ministry of Education and Culture (Ministry of Education) in 1965. Under this ministry, the education system evolved its present structure: one to two and a half years of pre-primary schooling for children aged from three (3) to five and a half years (5,5); six years of primary school for children aged from five and a half (5,5) to eleven and a half years (11,5); six years of secondary schooling, followed by two to three years of higher education for those who do not go for studies abroad (Solsten, 1991). Following, more details on these stages will be provided.

4. 1. 1. a. Pre-primary and Primary Education in Cyprus

Pre-primary education and primary education are very closely related and an evidence for this is that they share the same National Curriculum. The development of pre-primary education is a relatively recent phenomenon in Cyprus. In 1973 only eleven percent (11%) of children that were younger than five years old attended public or private nurseries or kindergartens. Following the 1974 invasion, the state became much more involved with pre-primary education through its establishment of nurseries and kindergartens for the thousands of refugees from northern areas. Pre-primary education is a particular priority since the Turkish invasion in 1974 in order to support refugee families, equalise educational opportunities across economic groups, and enable more mothers to secure gainful employment. The 1980s saw a further expansion of public education of this kind (Zembylas, 2002). Pre-primary institutions include public, private, and community-based nursery schools, day-care centres, and kindergartens.

The nursery schools are certified and supervised by the Ministry of Education whereas the day-care centres by the Department of Social Welfare and Services. A uniform curriculum is provided for the nursery school experience, promoting integrated development and preparation for citizenship. The Pancyprian School for Parents serves as a primary agency for parental education in Cyprus.

In September 2004, the Ministry of Education implemented compulsory pre-primary education for children aged from four and a half to five and a half years (Solsten, 1991). Today, education is compulsory in the early years, beginning at the age of three, and it is within the parents' jurisdiction to decide whether and when they should arrange a placement for their children in a public or private nursery school. After that, primary schools provide a six-year compulsory programme for children who have attained five years and nine months (insulaeuropae, n.d). Since 1962, primary education has been free and compulsory for children between the ages of six (6) to twelve (12). Schools operate in every community of at least fifteen (15) children. Area schools serve neighbouring communities with fewer than fifteen (15) pupils. Parental choice is not an option, and children must attend the school in the area where they live.

4. 1. 1. b. Secondary Education in Cyprus

Secondary education, which is also free, just like pre-primary and primary education, is open to all children who complete primary schooling without examination. Secondary education extends over six years (from twelve to eighteen). It is divided in two cycles, each consisting of three grades: the lower or gymnasium (from twelve to fifteen) and the upper or Lyceum (from fifteen to eighteen). Education in Cyprus is compulsory up to the age of fifteen and almost a hundred per cent of the students reach this level because education in Cyprus is a high priority in all social groups. During the first stage, the gymnasium, all students are taught the same general subjects, with a special emphasis on humanities. The second stage consists of either the lyceum, which offers five main fields of specialisation (classical studies, science, economics, business, and languages), or a vocational-technical course (Solsten, 1991).

A principal challenge at the beginning of the 1990s was to provide a more responsive to the needs of the economy education. The first vocational-technical schools were established after independence in an attempt to provide the rapidly expanding economy with technicians and skilled workers. However, Cypriots retained a tendency to choose academic rather than technical courses, for reasons of social prestige. Cyprus, therefore, faced a chronic shortage of skilled workers and a high rate of unemployment for university graduates. In the second half of the 1980s, this trend ended. In the academic year 1986-87, only five point three percent (5.3 %) of students opted for the classical academic course of studies, compared with forty six point two percent (46.2%) in the academic year 1965-66. About half of all students chose to concentrate on economic and commercial courses, about one-fifth percent chose scientific courses and one-fifth percent, vocational-technical courses (Solsten, 1991).

Today, lyceum students are taught some main subjects which are compulsory for everyone but they also have to choose a number of subjects that they want to study in depth. Schools of the second category aim at providing industry with technicians and craftsmen. Vocational schools train many students for work in the country's important tourist industry; technical schools emphasised on mathematics, science, and training in various technologies. The above information is important for this study as it suggests that not all students are taught science during their secondary education; if they have not chosen science as one of their main subjects, it means that they were only taught science about one hour per week.

4. 1. 1. c. Higher Education

At the beginning of the 1990s, there were institutions for teacher training, specialised instruction, and informal education. As it has already been said, before the early 1990s, there was no university in the Republic of Cyprus, and until one opened in the early 1990s, undergraduate studies in subjects like teaching had to be pursued abroad. However, there was an abundance of qualified teachers for all levels and types of schools, as well as administrative personnel, all of whom were accredited by a special committee of the Ministry of Education (Solsten, 1991). Although Cyprus had no university of its own (the long-planned University of Cyprus was expected to begin enrolling students for some courses in 1991), many Cypriots studied at foreign universities, and the percentage of students studying at university level, 29 percent, was among the highest in the world. During the 1970s and 1980s, an average of more than ten thousand (10,000) Cypriots studied abroad annually. During the 1970s, more than half of these students were in Greece, and about one-fifth were in Britain. In the 1980s, the United States became an important destination for students going abroad, generally surpassing Britain. The number of women studying abroad increased markedly during the 1970s and 1980s, going from 24 percent in 1970 to 40 percent in 1987 (Solsten, 1991).

4. 1. 1. d. Teacher Qualification in Cyprus

Cyprus did, however, provide some opportunities for third-level training and in the late 1980s, it attracted some of those who earlier would have studied abroad. In 1987, there were seven public and ten private institutions of higher learning, where about one-fourth of the island's secondary school graduates enrolled. The public institutions were the Pedagogical Academy of the Ministry of Education, which trained kindergarten and primary school teachers; the Higher Technical Institute of the Ministry of Labour and Social Insurance, which trained mechanical, electrical, and civil engineers; the College of Forestry under the Ministry of Agriculture and Natural Resources; the School of Nursing, the School of Midwifery, and the Psychiatric School of Nursing under the Ministry, of Health; and the Hotel and Catering Institute under the Ministry of Labour and Social Insurance. Private institutions offered courses in business administration, secretarial studies, mechanical and civil engineering, banking and accounting, hotel and catering, and communications (Solsten, 1991).

As a result, in-service pre-primary teachers today may have graduated from the University of Cyprus or from the Pedagogical Academy of the Ministry of Education. They may also have studied at one of the recently qualified private universities of Cyprus or may have studied abroad mainly in Greece and Britain. This implies that in-service, as well as pre-service teachers, receive different kinds of training which can be difficult to identify. However, it is important to note that pre-primary and primary student teachers receive more or less the same training during their studies.

4. 1. 2. Cyprus' National Curriculum

Cyprus has had a national curriculum in science since its independence from the British in 1960 with reviews being undertaken since then (a periodic review of 15 years or more) compared to other countries in the European Union (e.g. Germany, the Netherlands, Italy, Portugal) or in Korea and New Zealand in which the curriculum is reviewed every six (6) to ten (10) years (Zembylas, 2002). In Cyprus, the third and latest curriculum was completed in 1994 including the curriculum for Natural Sciences as well (Ministry of Education, 1996).

Before the latest curriculum, a growing dissatisfaction about the curriculum and the assessment methods was expressed among many Cypriot educators. The school curriculum was seen as being slow to respond to the changes that Cyprus went through the years and failed to provide learning experiences. The new cultural and religious ties with Greece defined educational policies in Cyprus and the science curriculum plans in Cyprus were often modelled after those of Greece despite the differences Greece and Cyprus have regarding their economy, politics, geography and social issues (Zembylas, 2002). An example of the strong ties between Cyprus and Greece is that until 1994 Cypriot teachers used Greek science textbooks because there were no science textbooks written in Cyprus or teachers' support material to teach science. The preparation of school textbooks was the responsibility of committees of teachers and administrators, working in close cooperation with the educational authorities in Greece. Some instructional material for both primary and secondary education was donated by the Greek government (Solsten, 1991). Greece also provided the schools in Cyprus with modern teaching equipment.

4. 1. 2. a. Cyprus' National Curriculum throughout the years

Tables & Figures 1: The Development of Cyprus' National Curriculums through the years

1935	The curriculum of 1935 includes natural history and rural science, euphemism for gardening, which replace ordinary science.
1960	Science curriculum writers in Cyprus face the task of developing a curriculum which takes into account modern global values.
1991	An American curriculum expert from Texas is invited to Cyprus to evaluate the situation and her observations reveal the problematic state of elementary science education.
1994	Evidence that science teaching is problematic has accumulated over the years; therefore, the latest curriculum development in 1994 is a natural consequence of numerous concerns expressed by teachers, administrators and the ministry of education and culture.

As shown in the above table, in 1935 the main component of the colonial government's policy was agricultural education because the government felt that the local socioeconomic conditions in Cyprus justified an emphasis on rural training. Thus, the curriculum of 1935 included natural history and rural science, euphemism for gardening, which replaced ordinary science. The British colonial administration seemed to believe that the training of elementary school children in the school gardens and the teaching of rural science were, under the circumstances, effective substitutes for proper agricultural education. Later, in 1960, science curriculum writers in Cyprus had to develop a curriculum that would take into account modern global values, including colonial ones, without destroying traditional ones (Papadakis, 2008).

Further on, in 1991, Stone, an American curriculum expert from Texas was invited to Cyprus to evaluate the situation and her observations regarding the problematic elementary science education were hardly surprising. According to Zembylas (2002), Stone's report indicated that the time allotted for Natural Sciences was the minimum and teachers were not properly prepared to teach most topics in Natural Sciences. In addition, she noticed that instruction was achieved through reading texts and answering fact-oriented worksheets whereas limited Natural Sciences' material and equipment, if any, were only available at schools for those teachers who wished to utilize activities in their lessons.

As Stone (1991:4) specifically highlighted: '*there should be a multi-year plan from writing, piloting, modifying, and implementing a complete science curriculum for all primary grades. The curriculum should be specific enough to provide both content/topic areas for each grade level and complementary* *instructional strategies, yet flexible enough to allow for individual teaching differences/skills among teachers' (cited in Zembylas, 2002).*

The latest curriculum development in 1994 was a natural consequence of numerous concerns expressed by teachers, administrators and the Ministry of Education, as evidence like the above accumulated over the years and indicated that Natural Sciences' teaching was problematic. The administrators and the ministry officials received Stone's observations positively and efforts began for the revision of the elementary science curriculum which affected the early-year's curriculum as well (Zembylas, 2002). These efforts became synonymous with the development of new instructional materials and mainly new textbooks and teacher's guides (which never existed before).

4. 1. 2. b. Cyprus' National Curriculum Today

As a result, today we have a National Curriculum which was last revised in 1996 (Ministry of Education, 1996). It covers pre-primary and primary education as well. The main underlying theoretical perspective was formed by a) Stone, b) the inspector committees and c) the Department of Curriculum Development for Science. This ended up in writing the textbooks and the teachers' guides. Moreover, professors teaching at the Pedagogical Institute and the Department of Education and a number of in-service teachers identified as enthusiastic about science contributed to these efforts (Zembylas, 2002).

The new curriculum was based on the Piagetian hierarchical-developmental views of learning and the main underlying philosophical perspective was 'guided discovery' (Ministry of Education, 1996). This approach emphasises the engagement of students in discovering scientific concepts for themselves. The students are guided to the desired objectives and conclusions with careful planning and direction. The policy statements on Natural Sciences, on the role of the teacher, and on Natural Sciences learning reflect this view and show the emphasis of the new philosophy on both the acquisition of scientific facts and principles and the implementation of scientific methods and skills. The objectives of the curriculum are concerned with providing the children with the scientific skills for the investigation and the understanding of Natural Sciences (Zembylas, 2002).

The curriculum revolves around thirteen (13) major themes or topics, which are structured in a 'spiral' way, so that they are taught over a period of several years, beginning with concrete experiences and moving to more abstract and in depth analyses. The scientific knowledge, skills, and attitudes to be learnt are stated in broad terms but provide enough guidance to teachers as to 'what to teach and when' (Zembylas, 2002). Especially the teachers' guide (reference book), as the basic tool for guiding the teachers, has lessons that are analysed in detail so that the teachers are helped as they prepare to teach the material (Nicolaou & Kiriakidou, 2004).

According to the curriculum developers, the teachers can follow the given suggestions but they can change and adjust some of them depending on the grade level they teach. However, they need to keep in mind that they should not be against the 'acknowledged and generally accepted principles' of Natural Sciences teaching. On the other hand, the aim of the textbooks is to help the teacher design the weekly Natural Sciences lesson, to offer the teacher the necessary worksheets based on the activities each lesson requires, to help teachers evaluate their teaching and to help the students understand and assimilate basic concepts and to acquire and develop scientific skills and right attitudes towards the teaching of Natural Sciences (Zembylas, 2002).

4. 1. 2. c. Cyprus' National Curriculum for Natural Sciences

According to the Cypriot National Curriculum, children have a natural curiosity which makes them want to investigate and comprehend the world around them and how it works. School is considered to be responsible to strengthen the curiosity that children already have and guide them through their journey to improve their investigating skills, problem solving skills and enrich their scientific knowledge. The Cyprus' National Curriculum recognises that Natural Sciences lessons should be connected to the children's everyday experiences in order to enable the children develop their scientific perceptions (Ministry of Education, 1996).

Communication constitutes an integral part of the Natural Sciences' activities and helps the children to develop their skills to collect and present information. These skills have to do with the careful observation, the linguistic expression as well as the expression via drawings, simple graphic representations, models and dramatisations. Natural Sciences learning includes activities like observing the environment, taking care of animals and plants, studying the natural phenomena and making experiments which are the main sources from where children draw scientific content knowledge and activities which require children to make comparisons, find similarities and differences, make tests/experiments and derive conclusions which also help the children develop scientific skills and have beneficial repercussions in the whole learning procedure (Ministry of Education, 1996).

4. 2. Children's Learning

Children's learning in science is about understanding the world around them (Guest, 2003). Thus, theories of learning deal with the ways a child learns, whereas, theories of teaching deal with the ways with which a teacher influences a child to learn. There is a close relationship between what a child learns and the variables that influence learning. As a result, once they have found out how children learn, teachers can help them learn better (Ausubel, 1968).

4. 2. 1. Constructivism

The opinion that *'...knowledge is not transmitted directly from one knower to another, but is actively built up by the learner'* is shared by a wide range of different research traditions relating to Natural Sciences education (Driver, Asoko, Leach, Mortimer, Scott, 1994, p.5). As a theory of learning, constructivism can be traced to the eighteenth century when the philosopher Giambattista Vico said that humans can understand only what they have constructed by themselves (Thanasoulas, n.d). Constructivism has roots in philosophy, psychology, sociology and education. It is the label given to a set of theories about learning, which fall somewhere between cognitive and humanistic views. If behaviourism treats the organism as a black box, cognitive theory recognises the importance of the mind in making sense of the material with which it is presented and it presupposes that the primary role of the learner is to assimilate whatever the teacher presents (Atherton, 2009).

Constructivism sees all knowledge to be instrumental (von Glasersfeld, 2002). Its central idea is that children's learning is constructed and learners build new knowledge upon the foundation of previous learning. Thus, the learner is much more actively involved in a joint enterprise with the teacher constructing new concepts and learning is not thought as a passive transmission of information from one individual to another (Atherton, 2009; Hoover, 1996; Jaworski, 1993). The emphasis is on the learner as an active 'maker of meanings'. It is the learner who interacts with the environment and, thus, gains an understanding of its characteristics in order to construct conceptualisations and find solutions to problems; this will lead to autonomy and independence (Thalasoulas, n.d). Distinctions can be made between 'cognitive/personal constructivism' and 'social constructivism' which share many common perspectives about teaching and learning even if they are different in emphasis.

The first one, 'cognitive/personal constructivism' is about how the individual learner understands things, in terms of developmental stages and learning styles. This tradition focuses on personal construction of meanings; people develop many informal theories about natural phenomena, which are a result of their personal interactions with physical events in their everyday lives (Driver et al., 1994). From this point of view, classroom learning should include activities that will be practical, well-designed and that will challenge the learners' prior conceptions encouraging them to reorganise their theories. The second tradition, 'social constructivism', emphasises how meanings and understandings grow out of social encounters. From this point of view, the knowledge-construction process comes through the learners being en-cultured into scientific discourses (Driver et al., 1994). In practice, this suggests that children should be involved in group activities that will enable scientific practices.

Constructivist learning environments have some main characteristics even if there is a range of processes by which knowledge construction takes place (Driver et al., 1994). For example, constructivist learning environment provides multiple representations of the reality, which avoid oversimplification and represent the complexity of the real world. They also give emphasis on knowledge construction and not on knowledge reproduction, and they provide learning environments such as real-world setting or case-based learning instead of predetermined sequences of instruction. These kinds of environments are ones that encourage thoughtful reflection on experiences and support collaborative construction of knowledge through social negotiation rather than through competition among learners for recognition. Finally, constructivist learning environments emphasize authentic tasks in a meaningful context rather than abstract instruction out of context (Jonassen, 1994 cited in Chen, 2007).

Having explained the main principles of constructivism, the table below offers a brief look into the main characteristics of this theory as opposed to the objectivist's view. Their main difference is that the objectivist's view sees knowledge as something that can be transferred from teacher to children or from some form of technology (including books) to children, whereas, the constructivist's view sees knowledge as something that individuals construct based on their interpretations of their experiences in the world (Walsh, 2004).

Tables & Figures 2: Constructivist's View Vs Objectivist's View

Objectivist's View	**Constructivist's View**
Knowledge exists outside individuals and can be transferred from teachers to children.	Knowledge has personal meaning. It is created by individual children.
Children learn what they hear and what they read. If a teacher explains abstract concepts well, students will learn those concepts.	Learners construct their own knowledge by looking for meaning and order; they interpret what they hear, read, and see, based on their previous learning and habits. Children who do not have appropriate backgrounds will be unable to accurately "hear" or "see" what is before them.
Learning is successful when children can repeat what has been taught.	Learning is successful when children can demonstrate conceptual understanding.

Constructivism's origin in science education is in many specific researches about different aspects of science education; from concept learning, problem solving or practical works to evaluation or attitude towards science. Such researches have been undertaken to improve poor results on the reception learning strategies, seriously questioned by research on 'alternative concepts', for example. Moreover, they aimed at involving children in the (re)construction of scientific knowledge instead of just transmitting it in order to make a meaningful and lasting learning possible (Kallery & Psillos, 2001; Psillos et al, 2003).

Constructivism in science considers children to be ‘novice researchers’, instead of just ‘scientists’, as the first one gives a better appraisal of the learning situation as a (re)construction of knowledge. The view of ‘the child as the scientist’ has been criticised as it is difficult to oppose the view that children by themselves cannot construct all scientific knowledge. It is a mistake to think that children are practising scientists working in frontier domains (Psillos et al., 2003). A constructivist’s approach for Natural Sciences learning means that the children develop their conceptual understanding and learn more about the scientific opportunity and support reflection.

4. 2. 1. a. Jean Piaget

Piaget was the first to put forward the notion that children construct their own knowledge which is different from that of an adult (Black & Lucas, 1993). Although Jean Piaget (1896-1980) was a biologist, he moved into the study of the development of the children's understanding through observing them, talking and listening to them while they worked on exercises he set. For Piaget, a child’s view of the environment and the way that it operates is different in nature as well as degree of sophistication from that of an adult (Driver & Easley, 1978).

Although Piaget did not refer to himself as a “constructivist” until later in his life, the view that knowledge is constructed by the cognitive subject is central to his position. According to Driver et al. (1994), his main concern was the process by which humans construct their knowledge of the world. He was also interested in how knowledge develops, what changes occur and what laws govern those changes (Ravanis & Bagakis, 1998). Piaget believed that each person has personal cognitive schemes which evolve through a process of adaption to more complex experiences and new schemes come into being by modifying old ones. He also believed that social interaction can play an important role in promoting cognitive development; however, he characterised equilibration at the individual level as essential (Driver et al., 1994).

Tables & Figures 3: Piaget's Stages of Cognitive Development (Atherton, 2009)

Stage	Characterised by
Sensori-motor (Birth - 2 years)	**Differentiates self from objects** Recognises self as agent of action and begins to act intentionally: e.g. pulls a string to set mobile in motion or shakes a rattle to make a noise Achieves object permanence: realises that things continue to exist even when no longer present to the sense
Pre-operational (2 - 7 years)	**Learns to use language and to represent objects by images and words** Thinking is still egocentric: has difficulty taking the view point of others Classifies objects by a single feature: e.g. groups together all the red blocks regardless of shape or all the square blocks regardless of colour

Concrete operational (7 - 11 years)	**Can think logically about objects and events** Achieves conservation of number (age 6), mass (age 7), and weight (age 9) Classifies objects according to several features and can order them in series along a single dimension such as size.
Formal operational (11 years and up)	**Can think logically about abstract propositions and test hypotheses systematically** Becomes concerned with the hypothetical, the future, and ideological problems

The table above provides information on Piaget's stages of cognitive development. The stages propose that there are certain points where the children's thinking 'takes off' and moves into completely new areas and capabilities (Atherton, 2009). For Piaget, this happens at about 18 months, 7 years and 11 or 12 years. This implies that, before these ages, children are not able to understand things in certain ways. His research on how children's minds work and develop has influenced the educational theory, especially his opinion about what an important role maturation plays in regard to the children's increasing capacity to understand their world: they cannot undertake certain tasks until they are psychologically mature enough to do so. However, it is worth mentioning that many children manage concrete operations earlier than Piaget thought, although some people may never attain formal operations. Piaget's research generated a great deal more, much of which has undermined the detail of his own, but like many other original investigators, his importance comes from his overall vision (Atherton, 2009).

Piaget’s constructivism is premised on his view of the psychological development of children. According to his theory, the basis of learning is discovery and understanding which are built up step by step through active participation and involvement (Thanasoulas, n.d). For him, this is necessary for a child in order to be capable of being productive and creative and not simply repeating other people’s ideas. Research into the children’s preconceptions has at least one important characteristic in common with Piaget’s work which is that “it takes the child’s view of the world seriously” (Black & Lucas, 1993, p.20). For Piaget, the child constructs his own logical concepts rather than discover them. Since concepts do not exist ‘out there’, they just cannot be discovered simply by being exposed. Within this framework, it is possible that some of the activities performed in nursery schools have to be devoted to the systematic initiation of science and phenomena (Ravanis & Bagakis, 1998).

Concluding, constructivism is thought to be the basic theory behind children’s learning as it implies that children construct their knowledge based on what they already know. Therefore, the children’s own constructed concepts determine how they perceive the world. In this sense, if children receive the appropriate guidance, they can have their own mental frameworks broken by constructing a new one (Nussbaum, 1989). This study considers that the children’s sense of science depends on their ability to process information and this is both a function of what they already know and of their own thinking skills. Their development of thinking and, thus their learning, may be linked with brain maturity and cognitive development and this maturation could be similar to the stages identified by Piaget (Guest, 2003).

4. 2. 1. b. Social Constructivism

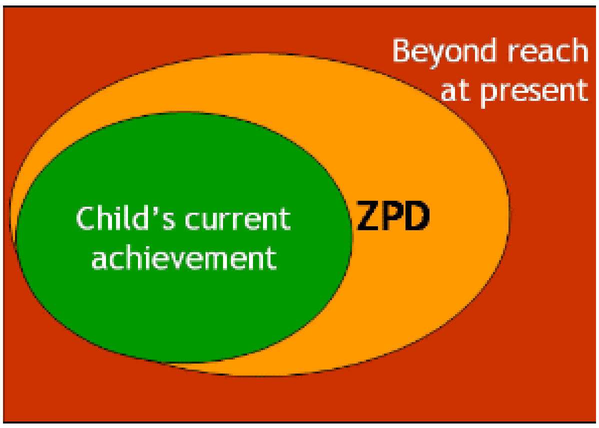
Social constructivism is more about how meanings and understandings grow out of social encounters in contrast to cognitive constructivism which is about how the individual learner understands things, in terms of developmental stages and learning styles (Atherton, 2009). Chen (2007) noted that there is a great deal of overlap between cognitive constructivism and social constructivism theory. Social constructivism emphasises more on the role that the teacher has and it gives much more room for an active, involved teacher. Culture is considered to give the child the cognitive tools needed for development. The type and quality of those tools establish the pattern and rate of development to a much greater extent than they do in Piaget's theory. Adults such as parents and teachers are conduits for the tools of the culture, including language. The tools the culture provides a child with include cultural history, social context, and language. Today they can also include electronic forms of information access (Chen, 2007).

4. 2. 1. c. Lev Vygotsky

The most significant bases of a social constructivist theory were laid down by Vygotsky (1896-1934), who shared many of Piaget's assumptions about how children learn but placed more emphasis on the social context of learning. Piaget's cognitive theories have been used as the foundation for the discovery of learning models in which the teacher plays a limited role. In Vygotsky's theories, both teachers and older or more experienced children play a very important role in the children's learning (Chen, 2007). From this perspective, a person with more experience can support a less experienced one to perform tasks and internalise processes since knowledge constructs through social engagement and dialogic activities (Driver et al. 1994).

Lev Vygotsky pioneered research in learning sciences and made a strong argument for the need the children have to demonstrate their knowledge by creating explanations and interpreting their work for others (Carvin, n. d). Vygotsky's basic theory is the 'Zone of Proximal Development' (ZPD). In the 'constructing skills' check lists, it is common to have 'cannot do yet', 'can do with help', and 'can do alone' as possible answers. The ZPD is about 'can do with help' not as a permanent state but rather as a stage towards being able to do something on your own. Vygotsky's view was that instruction created within the Zone of Proximal Development (picture 1.1) stimulates development. From this point of view, instruction cannot be identified as development, but properly organised instruction can result in the child's intellectual development, can bring into being an entire series of such developmental processes, which would not be possible without instruction (Leat & Nichols, 1997).

Tables & Figures 4: Zone of Proximal Development according to Vygotsky (Atherton, 2009).



Vygotsky also observed that when children were tested on tasks on their own, they rarely did as well as when working in collaboration with an adult. The case was not that the adult was teaching them how to perform the task, but that the process of engagement with the adult enabled them to refine their thinking or their performance to make it more effective (Atherton, 2009). To Vygotsky, teachers served as mediators who coached and encouraged children to formulate their own level of understanding. Each child has a base level of knowledge, but they can increase it by practicing what they know well and adding onto it. The social interaction between the child, the teacher and other children reinforces their increase of knowledge (Carvin, n.d).

4. 3. Children's Understanding of Science

When investigating the children's preconceptions, it is necessary to explain the way that children learn new concepts and construct their knowledge. In order to understand that, we need to make a reference on the children's innate understanding of science and how this is developed. The children's concepts are thought to have been formed as the result of previous experiences. Much of young children's scientific learning comes from the varied environment in and around their homes, the information that is shared around them and the skills' demonstration by close adults like their parents (Bradley, 1996; Hollins, Whitby, Lander, Parson & Williams, 2001). Jill de Kock (2005) agrees and adds that the children's scientific views are a result of personal experiences, which can include watching television, reading books and oral language interactions in addition to the interaction with family members and other adults. Similarly, Roth and

McGinn (1998) said that science is part of the children's life from the very beginning through television science programmes, visits to science museums etc. Guest (2003) explains that the children can be influenced by folklore (that eating carrots helps you see better during night time), or the media (that spaceships explode with sound).

Bradley (1996) further explains that the children's innate understanding of science is acquired by physically using scientific principles in their play long before facing formal education. For instance, when children use a see-saw, they experience that by pushing up one end of the see-saw, the other end will go down, even if they may not be able to verbalise their understanding in terms of physics. Even bath time can be a stimulus for children since while playing with bath toys, they can experience sinking and floating (when they push bath toys under the water some of them will sink and some others will come back up). As a result, from the moment of birth (and some might say from the moment of conception) the children's physical and social experiences through their personal exploration can lead them to develop their scientific understanding about the world around them (Johnston, 2005).

Furthermore, Johnston (2005) adds that early-years children have some very firm cognitive concepts as a result of a whole range of experiences which can be wide ranging and diverse even if they are sometimes limited in understanding. The importance of these firm cognitive concepts in education is that they have a remarkable influence on the children's subsequent cognitive development. Based on this, she suggested that teachers need to be aware of the children's early-year experiences as those experiences are diverse and numerous and they are important in order to help the children develop scientific concepts, skills and attitudes in the world of teaching. Nevertheless, it is helpful to be aware and know not only the children's experiences but also our own experiences and alternative concepts as teachers (Johnston, 2005).

In regard to the children's concepts, Johnston (2005) divided those concepts into 3 different categories. The first category, "factual knowledge", refers to those concepts that children adopt through first-hand experience or secondary sources like television and books. The second category, "fictional knowledge or myths", refers to secondary sources of knowledge like tales and stories. This is the reason why children are not always able to differentiate fact from fiction (Johnston, 2005). The third and last category is called "inferred knowledge" and it is about the children's concepts that result from an interaction between their practical experiences and the existing concepts that they hold. These concepts may be inaccurate and can have a profound influence on further conceptual development (Johnston, 2005).

4. 3. 1. Children's Acquisition of Concepts

Historically, the young children's conceptions of science were not considered to be investigable as it was thought that children could not understand scientific phenomena (de Kock, 2005). However, according to Greenfield (cited in Guest, 2003), research relating to brain development indicates that a child's brain develops neurologically during the first years of life (from zero to six years old). This is the time when the brain becomes 'wired' and develops the neurological connections needed to make sense of experiences. Therefore, research has begun to accept that the learning of concepts and conceptual change is in the centre of Natural Sciences learning for young children (Nussbaum, 1989).

'The acquisition of concepts is what makes learning possible' (Osborne & Gilbert, 1980). Thus, it is significant for science education research to understand how the children's concepts are formulated. Accepting this view signifies the desire to investigate the children's understanding of basic concepts as it informs teachers for the need to be aware of the possible perspectives children may bring to and difficulties children may have in Natural Sciences lessons (Osborne & Gilbert, 1980). Concepts can be thought of as "ideas or general notions of the attributes that are common to a class of objects or events" (Bradley, 1996, p.43). According to Bradley's definition, the concept of "cat" would encompass all the essential qualities that are the same for all cats (four legs, tail, meat eater, facial whiskers etc), but would also apply to the big cats (lion, tiger etc).

To avoid this, Bradley (1996) explains that concepts can be subdivided into smaller concepts that help us distinguish a puma from a tiger or a cat. By dividing the concepts into smaller "sub-concepts", they become more specific and restrictive, whereas the larger the concept, the more wide-ranging and abstract it is. Similarly, scientific concepts can be seen as "those ideas or general notions of the common attributes of objects or events that help us to understand the natural and physical world around us" (Bradley, 1996, p.43). Those ideas or else concepts enable us to appreciate the patterns and relationships between the way things are made and the way they behave, whether it is the different forms that water can exist (liquid, gas or solid) or why and how a shadow appears.

On the other hand, while criticising Vygotsky's work, Daniel (2002) realised that for Vygotsky scientific concepts are characterised by a high degree of generality and their relationship to objects is mediated through other concepts. Vygotsky divided concepts into 'scientific concepts', which are the ones introduced in a school by a teacher, and 'spontaneous concepts', which are those acquired by the child's outside contexts in which explicit instruction is in place (Daniel, 2002). He added that for Vygotsky the most important concept is the one of "mediation" which opens the way for the development of a "non-deterministic" account in which the individual acts upon and is acted upon by social, cultural and historical factors" (Daniel, 2002, p.14). In all cases, the theoretical structure of the concepts, the attributes of the concept, the relationship between the concept and other concepts and the various contents associated with the concept, all need to be considered (Osborne & Gilbert, 1980). The children's concepts affect the way that children understand a variety of scientific concepts like, for example, the fact that some students know that the Earth is round but they believe that Earth is a planet somewhere in the sky but not the planet they live on (Eaton, Anderson and Smith, 1984).

As a result, children develop their ability to think and their concepts slowly and in regard to their experiences and interactions. The information capability of a specific child can set limits on the complexity of concepts that the child is able to cope with. As Guest (2003) contends, concept development is not just a case of becoming faster or fuller of knowledge; there are also qualitative changes in the way that children process new information as they develop cognitively.

It is important to note that there are cases the child may not understand the concept in the way it was intended in the communication or the child might understand the intended concept but the particular context may suggest a different interpretation of the concept. This refers to the child's understanding of a particular communication (e.g. via a teacher or a textbook). On the other hand, there are cases in which the concept is clearly specified through a given formal statement or definition which is accepted by the child as a definition that can be understood in the children's actual domain of understanding of a particular concept (Daniel, 2002). As a result, apart from the problems a child faces when not understating a concept, these additional obstacles can create hidden difficulties.

4. 3. 2. Examples of Children's 'Incorrect' Concepts

Children's conceptions are strongly supported by personal experience and socialisation into a 'commonsense' view. According to Driver et al. (1994), a worldwide research has shown that the children's informal science concepts are not completely different for each individual. There are common informal ways of modelling and understanding phenomena that are found among children from different countries, cultures, educational systems and languages. For example, children in different countries share the concepts that matter can appear and disappear or that gases do not have weight (ibid, 1994).

Researchers have also examined the learners' understanding of specific science concepts and have uncovered concepts held by learners that do not agree with what is generally accepted by the scientific community (Snyder & Sullivan, 1995). As an example, Bradley refers to a four-year-old child and his explanation about why it rains. The child said "It rains because the sun shines on the top of the clouds and pushes the rain out and it rains down to us" (Bradley, 1996, p.3). A further example refers to the children's confusion about shadows: "I think a shadow is a reflection from the Sun. Sometimes, when you look in a pond, you see a reflection. When you go somewhere where it can reflect, you see your shadow" (Russell & Watt 1992 p.81). Examples like these can be found in all areas that are taught in Natural Sciences. The topics taught in Cypriot early-year public schools are shown in Table 1.3 along with one example for each one of them.

Tables & Figures 5: Topics and examples of 'incorrect' concepts

Plants and Animals	Plants take their food in through the roots and then store it in their leaves.
Human body	The eye is the only organ for sight; the brain is only for thinking.
Weather – Earth - Space	The earth is sitting on something.
Ecology	Plants only give off oxygen.
Matter	Gases are not matter because most are invisible.
Magnets	All metals are attracted to a magnet.
Light	Light is associated only with either a source or its effects. Light is not considered to exist independently in space; and hence, light is not conceived as 'travelling'.

Sound	Human voice sounds are produced by a large number of vocal chords.
Heat - Energy	Things 'use up' energy.
Electricity	Batteries have electricity inside them.

(Ministry of Education in Cyprus, 1996; American Institute of Physics, 1998; Missouri Department of Elementary and Secondary Education (M.D.E.S.E), 2005)

Some studies, like the ones carried out by the American Institute of Physics, have managed to design lists with the children's common 'incorrect' concepts. The following list is a mixture of such 'incorrect' concepts in regard to 'water cycle', as this is the target topic for this study.

- Rain comes from holes in clouds.
- Rain comes from clouds sweating.
- Rain occurs because we need it.
- Rain falls from funnels in the clouds.
- Rain occurs when clouds get scrambled and melt.
- Rain occurs when clouds are shaken.
- Clouds come from somewhere above the sky.
- Empty clouds are filled by the sea.
- Clouds are formed by vapour from kettles.
- The sun boils the sea to create water vapour.
- Clouds are made of cotton, wool or smoke.
- Rain falls from clouds when they collide and split open.

- Rain falls when clouds get cold.
- When water evaporates, it just disappears and ceases to exist.
- When water evaporates, it immediately goes up to the clouds or into the sun.
- Students have a difficult time accepting the concept of invisible particles of water in the air. (American Institute of Physics, 1998; M.D.E.S.E, 2005).

The above list is an example of how many different concepts children can have in regard to one specific topic. The problem though is that children develop these concepts which can then persist despite instruction. There are cases in which children were exposed to formal models or theories and had assimilated them incorrectly (Driver & Easley, 1978). This might suggest that children relate new knowledge to existing knowledge and, thus, when the existing knowledge is 'incorrect', it might lead to making wrong connections.

4. 3. 3. Specific Research Examples

Systematic researches into children's concepts in science began in the late 1970s and most of them focused on secondary level. The main work at the primary level began with ground-breaking studies in New Zealand in the 1980s, and the SPACE[2] project in the UK which studies the children's concepts across the full range of the curriculum for children aged five to eleven years (Harlen & Qualter, 2004). Since then, researchers have been aware that the children's conceptions, regarding Natural Sciences, are sometimes different from scientific conceptions (Eaton, Anderson and Smith, 1984). Treagust (1988) explains that most researchers followed Piaget's approach to probing children's thinking

[2] SPACE project will be further discussed later on.

through individual students' interviews. During the last two decades there has been considerable research in this area and, according to Eaton, Anderson and Smith (1984), this research has demonstrated that students use their knowledge of the world to comprehend and their comprehension usually results from preconceptions or alternative concepts inadequacies (an explanation on these terms will be given later) in their background knowledge.

Eaton, Anderson and Smith (1984) aimed at finding out if the student's alternative concepts interfered with science learning. The study is part of the Elementary Science Project and it focuses on the teaching of science of fourteen teachers, five of whom taught about light and nine about photosynthesis. As the researchers report, the teachers were selected because they were within driving distance and because they taught regularly. The data were collected through observations and audio-recordered lessons on the unit of light (Eaton, Anderson and Smith, 1984). It is worth mentioning that before the light and seeing unit was taught, children took a test which they took again after the unit had been taught. The results showed that students had difficulties in learning about light because neither their text nor their teachers dealt with their alternative concepts adequately. Specifically, they wrote that "experiences and common sense can sometimes lead to inaccurate or incomplete conceptions that can prevent a student from learning" (Eaton, Anderson and Smith, 1984, p.1).

Another interesting example is given by Osborne and Cosgrove (1983), who did a research on the children's alternative concepts about phenomena associated with water and, specifically, the children's conceptions of the changes in the state of water; for example, evaporation, condensation and boiling, and melting of ice. Their investigation was based on the clinical interview technique. Forty-three children from eight to seventeen years old were individually interviewed using a series of events which involved ice melting, water boiling, evaporating, and condensing. For each of these events, the children were asked to describe what they saw happening and explain what had happened. Each interview lasted thirty minutes and was audio-taped; finally, the tapes were transcribed and analysed (Osborne and Cosgrove, 1983).

The sample of children for Osborne and Cosgrove's (1983) research was selected from a range of classrooms with each classroom teacher selecting the child in order to establish the range of views held by children of average to slightly above average scholastic ability. The analysis of the interviews showed that children bring strongly held views in relation to their experiences to science lessons and these views appear to them as logical and sensible. For example, children have concepts about the changes in the state of water but these concepts are quite different from the views of scientists. Another important result of their research was that the concepts children have can sometimes be influenced by science teaching in unintended ways (Osborne & Cosgrove, 1983).

Research into the children's concepts about the nature of light showed that teachers usually take the children's concepts on school science for granted and the only definition given is that light is 'a form of energy' (Driver, Squires, Rushworth & Wood-Robinson, 2001). For example, most ten and eleven year-old children do not recognise light as 'a physical entity existing in space between the source and the effect that is produced' (Driver et al., 2001, p.128). In addition, an investigation into the children's understanding of sources of light showed that children between seven and eleven year-olds talk about primary sources almost four times more than they talk about secondary sources of light (Driver et al., 2001, p.128). The same research studied the children's representations of light and it found that almost all children drew the light around sources by using short lines while the extensive number of lines linking the source with the object was limited. A few children did not use any representation and for others the representation was limited to simple lines surrounding the source (Driver, et al., 2001, p.128). The above research example suggests that children hold some 'incorrect' concepts which may affect their acquisition of new concepts in negative ways.

Another research example is the one of Valanides, Gritsi, Kampeza & Ravanis (2000) which is interesting as it was conducted in Greece with early-years children and focused on changing pre-school children's conceptions of the day / night cycle. A sample of thirty three (33) children (twenty-five (25) girls and eight (8) boys) whose mean age was five point five (5.5) years was interviewed in order to identify the children's concepts about the shapes of the Sun and the Earth as well as the cause of the day / night cycle. The sample of the children was randomly selected from the total number of five- (5) to six- (6) year-old children in three (3) kindergartens and none of the children had already received any formal or informal instruction concerning the respective topics. The selected kindergartens were in an urban area with a population of mixed socio-economic status.

The interviews used were semi-structured. A teaching intervention based on the constructivist's view, which was designed to teach pre-school aged children about the Sun and the Earth and the day / night cycle, was implemented. The teaching intervention took place with groups of six (6) or seven (7) children, lasted for approximately thirty (30) minutes and one researcher was teaching while the second one was assisting. The effectiveness of the intervention was evaluated two (2) weeks later using an interview similar to the one used prior to the intervention (Valanides et al., 2000).

According to Valanides et al. (2000), the results of the study indicated that the majority of children easily accepted that the Sun and the Earth are different spherical objects, but fewer children attributed the day / night cycle to the Earth's rotation on its axis. Most children seemed puzzled by the simultaneous movements of the Earth around the Sun and around its axis. The results of this research support the view that children do not passively absorb information. They bring their own views of the world to any teaching learning situation. For the specific study, the range of the preconceptions about the shapes of the Earth and the Sun as well as the cause of day / night cycle are the outcomes of a personal construction process showing that individuals construct their own meanings from sensory inputs. This is even more important when there is a sequence in which concepts are acquired on a conceptual domain (Valanides et al., 2000).

Finally, another research example focusing on Greek early-years children is the one of Ravanis and Bagakis (1998). Their research is an example of the socio-cognitive perspective. With this research, they tried to detect early-years children's mental representations of gasification of water and, also, to destabilise and transform the children's intuitive concepts and representations through a teaching intervention. The focus on the changes in the states of matter, and specifically water, can be really helpful as this will be the focus of this study as well. According to Ravanis and Bagakis (1998), the sample of the research was taken at a Greek kindergarten. The sample consisted of forty-nine (49) randomly selected children with an average age of five and a half years old (5.5) and their parents had no specific education in science.

Ravanis and Bagakis (1998) used a pre-test and a post-test which included semi-structured interviews that were reordered, and a teaching intervention half-way the interview. During the pre-test and the post-test a small plate with a small quantity of water was placed on a camping-gas stove and the children were asked to predict what would happen if the water was heated for a long time. During and after the experiment, a discussion about the phenomenon took place.

The teaching intervention took place a month after the pre-test and aimed at helping the children understand and be able to describe how the transformation from the liquid to the gas state was done. The activity was done by each child individually in a specially designed space in the school, outside the classroom. Ravanis and Bagakis (1998) pointed out that their strategy had a socio-piagetian approach based on the student - teacher interaction. It included the comments of a series of pictures with the gasification and liquefaction phenomenon and the observation and comments of the gasification and liquefaction process in a simple transparent distillation apparatus. Although the liquefaction process was not included in the objectives of the teaching intervention, it was used since the observation of an elementary water cycle was thought to be helpful for children to relate water vapour to water (Ravanis & Bagakis, 1998).

The results of the above study and the data analysis of the pre-test and post-test indicated, firstly, that the children were not able to predict the evolution of the phenomenon (during the pre-test) and their answers were strongly influenced by their everyday experiences. Additionally, when the children were asked ‘where does the water go?’, some of them gave efficient answers (in the air, it becomes vapour and leaves upwards), some others made hypotheses and gave answers based on the experimental apparatus (the water went into the bottle of the camping-gas, it was sucked by the desk, it went to the soil) and some did not give an answer (Ravanis & Bagakis, 1998). It is worth mentioning that the number of correct answers was bigger after the teaching intervention (pre-test: 3-4 correct answers, post-test: 43-44 correct answers). This might indicate that the socio-cognitive perspective of the teaching interaction and the student-teacher interaction can help children overcome their cognitive obstacles. However, teachers are not always able to have one-to-one sessions with their students like the specific researchers did.

4. 3. 4. Labelling ‘Incorrect’ Concepts

Children bring certain concepts, similar to the ones in table 1.1 above, into Natural Sciences lessons that are well-established in their way of thinking. These concepts are sometimes inconsistent with the concepts that teachers and scientists have (Treagust, 1988; Pine, et al., 2001). The children’s conceptions which differ from those generally accepted by the scientific community have been labelled differently by different authors (Guest, 2003; Hamza & Wickman, 2007). For example, Helm (1980) refers to them as ‘misconceptions’, Ausubel (1968) and Novak (cited in Hamza & Wickman, 2007 chose to call them ‘preconceptions’, whereas Driver (1981) preferred the term ‘alternative frameworks’ and Gilbert et al. (cited in Treagust, 1988) labelled them as ‘children’s science’ (Driver, 1981). Other authors used labels such us ‘alternative conceptions’, ‘intuitive theory’, ‘non-scientific ideas’ and ‘children’s ideas’ (Guest, 2003; Hamza & Wickman, 2007).

In 2007, with a search on ERIC, Hamza & Wickman found three hundred and twenty-eight (328) hits for “misconceptions” AND science between the years 2000 and 2006, whereas a search for science AND “alternative conception”, “alternative framework” or “intuitive theory” gave forty two (42) hits altogether. Today, with a search on ERIC, more than 2000 hits are found for “misconceptions” AND science, whereas a search for science AND ‘alternative concepts’, ‘alternative frameworks’, ‘intuitive theory’, ‘preconceptions’ or ‘non-scientific ideas’ gives fewer than 700 hits altogether. This is a remarkable difference which proves that the term “misconceptions” is the one most widely used in the literature. However, this cannot be taken as evidence that ‘misconception’ is the correct term for the purposes of this research. This is why a distinction needs to be made between some of the terms that have been used by authors in order to choose the most appropriate one to use in this study.

According to Treagust (1988), misconceptions are the children’s conceptions that differ from those generally accepted by the scientific community while Guest (2003) pointed out that a misconception can be a false or mistaken view, opinion or attitude. Another definition, given by Cohen and Kagan, (1979) is that misconceptions are the students’ attempts to integrate new and old understandings. From Andre and Ding’s (1991) point of view, misconceptions are concepts that children “have incorporated into their cognitive structures that they use to understand and make predictions about the world" (p.303). They reported that such knowledge is based on the students' experience which explains how the world works, but in an incorrect way (Andre & Ding, 1991). It seems that, in most cases, the term 'misconception' is used to describe the children's concepts that have the characteristics of incorrect models or theories.

However, the term misconception has an obvious connotation of 'a wrong concept' and, also, research reported on common misconceptions in various areas of science indicates that this term is usually used in studies in which the children have been exposed to 'formal models or theories and have assimilated them incorrectly' (Driver & Easley, 1978, p.61). On the other hand, in a situation where children have developed autonomous frameworks or have conceptualised their experience of the physical world, their concepts will be called 'alternative concepts'. Similarly, Driver (1981) stated that in some areas children hold beliefs which differ from the currently accepted view and from the intended outcome of learning experiences and this is what she named as 'alternative frameworks'. Finally, the term 'preconception' implies that the concepts expressed by the child do not have the status of generalised understanding characteristics (Clement, Brown & Zietsman, 1989). Ausubel (1968) was the first to use this term to refer to the children's concepts that are amazingly tenacious and resistant to extinction (cited in Driver & Easley, 1978). Preconceptions can often pose strong barriers to understanding physics and many of them are detrimental to learning (Clement, Brown & Zietsman, 1989). Preconceptions are detrimental to learning and they might lead to alternative concepts. However, it is worth mentioning that this is not always the case as there are some preconceptions which are largely in agreement with accepted physical theory. Clement, Brown and Zietsman (1989, p.555) referred to these as ‘anchoring conceptions’, or else, ‘anchors’ which are ‘an intuitive knowledge structure that is in rough agreement with accepted physical theory’.

As a result, for the purpose of this study which focuses on early-years children, the term ‘preconception’ will be mainly used. ‘Preconceptions’ will refer to early-years children’s concepts on science which differ from conventional scientific explanations or classifications and which have most likely been developed autonomously in relation with the children’s experiences and without much exposure to formal models or theories through education. In other words, the term ‘preconceptions’ will refer to early-years children’s concepts that have been formed after limited or no teaching and will focus on the specific area of the incorrect concept. On the other hand, the term ‘alternative concepts’ will be used to label the older children and teachers’ concepts that differ from those accepted by the scientific community as this group of learners has been exposed several times to formal models and theories in order to avoid using the term ‘misconceptions’ which might connect children with the negative connotation that the term has. However, the literature review for this study will include information by authors using different labels, as well, in order to avoid ignoring important information relevant to this topic.

Tables & Figures 6: *Terminology of preconceptions and alternative concepts for this study*

	Preconceptions	**Alternative concepts**
Age range	From birth – 7 years old	8+ years old and adults
Learners' Education	Limited or no exposure to science teaching	Repeated exposure to science teaching
Characteristics	Resistant to change	Resistant to change

4. 3. 5. How Preconceptions can be formed

Preconceptions like the ones mentioned above can be formed in various ways and they are often passed on by one person to the other and usually people who hold such concepts are not aware that their concepts are not correct (Hanuscin, 2007). This is why, when they are told that what they believe is incorrect, they find it difficult to overcome their beliefs, especially if they have had them for a long time (Hanuscin, 2007). This is very important because, as it has already been said, knowledge is constructed by building new understandings on previous conceptions and, if the previous conceptions are incorrect, the impact on learning is very serious. It is also important to mention that children who hold such incorrect concepts can convince others in a group to believe them (Snyder & Sullivan, 1995).

Worth (2000) believes that the children's preconceptions can arise from the children's own experiences. During childhood the children's concepts develop as a result of experiences and socialisation, thus, it is normal that everyday experiences will evolve with everyday ontological frameworks (Driver et al., 1994). Commonsense explanations have their role, as well, since they differ from the knowledge accepted by the scientific community since commonsense reasoning is usually free of rules in contrast to scientific reasoning (ibid, 1994). Language is another source of preconceptions since common words, which are also used in everyday life but do not have the same meaning when used in Natural Sciences, can confuse children and lead to preconceptions (Hanuscin, 2007).

Cohen and Kagan (1979) and Hanuscin (2007) agree and add that preconceptions can arise when two or more learnt concepts get mixed up. An example that Hanuscin (2007) gave when explaining this is that while it is acceptable to say “the toast burnt” in an everyday conversation, it is highly unlikely that a chemist would agree with this observation. Cohen and Kagan (1979) characterise this as verbal confusion and believe that it is the most common way to form a preconception which might lead to an alternative framework. We could say that preconceptions and alternative concepts arise from both verbal and conceptual confusion (ibid, 1979).

In addition, language used by teachers when teaching Natural Sciences might confuse children. Luisa, Veiga, Pereira and Maskill’s (1989) research results suggested that the children’s common preconceptions can be embedded in the linguistic metaphors and analogies used by the teachers when discussing with children because the children’s after school lives and experiences constantly reinforce the children’s non-scientific denotations of the words they use in Natural Sciences lessons. Teachers talk about science experiences with children and in order to communicate in a naturalistic way, they use words with everyday meaning alongside the same words used with their more precise scientific definitions. Thus, it is possible that preconceptions at a younger age and alternative concepts at an older age are reinforced by the teacher. Luisa et al.'s (1989) research revealed that the alternative concepts that children were known to have were similar to the misleading references used by the teachers in their everyday language in the classroom. The same added that in order to understand the meaning of words when they are first used in a scientific context, the children sum up all the connections to all the situations when they used these words in their lives; this indicates that most words can have multifaceted meanings and can confuse children. However, teachers cannot avoid all those common linguistic references which they cannot circumscribe with qualifying comments; teachers need to use naturalistic language that the children will be familiar with. However, they must be aware that 'the possibly conflicting ways of interpreting such natural expressions may, at the very least, slow good learning down' (Luisa, et al., 1989, p.477).

The above position was also accepted by Tiberghien (cited in Luisa, et al., 1989) who studied ten to fourteen-year-old children's alternative concepts on 'heat' and 'temperature'; she added that the development of the children's concepts is a result of teaching. Besides that, Tiberghien's research results indicated that most of the children's alternative concepts did not change after the lesson. As a conclusion, we could say that early-years children preconceptions and older children's alternative concepts might not be overcome, not even after exposure to formal teaching. Thus, it is important to investigate how teachers try to eliminate the children's preconceptions and prevent them from developing into alternative concepts.

4. 4. Teachers' Role in Natural Sciences Teaching

First of all, it should be made clear that teaching refers to the deliberate guidance of the learning processes (Ausubel, 1968). Therefore, the teacher is responsible to guide children through the learning process using the most effective methods of teaching. Sutton (1980), reported that the teachers have a complicated role when teaching Natural Sciences because, at the beginning, it is more diagnostic, trying to describe the learner's existing private concepts, while later the teacher feels more like a "provocateur" of its changes and extensions (Sutton, 1980). Teachers seldom have the time to identify the children's preconceptions and are often forced to assume a certain base level for the students' knowledge (Chen, Kirkby & Morin, 2006). However, knowing the students' common conceptions is essential for teaching (Tirosh, 2000).

Driver et al. (1994, p.6-7) highlighted that:

"T*he role of the science educator is to mediate scientific knowledge for learners, to help them to make personal sense of the ways in which knowledge claims are generated and validated, rather than to organise individual sense-making about the natural world... The teacher's role is to provide the physical experiences and to encourage reflection*".

Russell and Watt also (1992) pointed that the teacher's role in Natural Sciences teaching is to help children develop their understanding starting from concepts that they already have. As the Project specifies, this role expects the teachers to:

- Plan topics or areas of investigation around the development of understanding of key concepts and skills,

- start a topic of investigation by giving children opportunities to explore and then express their concepts about their explorations,
- discuss with children their reasons for holding their particular concepts,
- use one or more strategies to help children develop their concepts, based on the nature of the children's concepts and how these relate to the key concepts the teacher has in mind,
- review the extent to which concepts have developed with children and
- plan further experiences to take the development further.

In 1987, Duckworth (cited in Driver et al., 1994) described the kinds of interactions that would help to properly listen and respectfully question the children's meanings. These would be to use questions like: "What do you mean?", "How did you do that?", "Could you give me an example?", "How did you figure that?'. Questions like these can help to take the children's thoughts a step further.

In researching teachers' responses to the understandings of conceptions, Pine et al. (2001) highlighted that the role of the teacher is to organise the child's preconceptions into coherent concepts which are accurate and explicit. Their research revealed that the teachers describe a range of methods that can be used to find out what the children already know, including discussions, brainstorming, predicting etc. They added that "teachers believe that false beliefs get in the way of the teaching process, and are best ignored or squashed as quickly as possible" (Pine, et al., 2001, p.92). Their findings suggest that the children hold many incorrect concepts about Natural Sciences' topics and that these concepts are of considerable importance for teachers as it suggests that they had better not be ignored in the learning process since they are the foundations upon which the knowledge is built. This suggests that there is a need for teachers to place as much emphasis on the children's wrong concepts as on their correct ones if they wish to teach Natural Sciences concepts effectively (ibid, 2001).

Children have differences in maturation and pre-school experiences as they develop differently and at different rates. For example, Johnston (2005) highlighted that not all parents are aware of the need to provide different experiences for their children outside school and as a result, we have classes with children of mixed abilities and experiences. This makes the teacher's role even more challenging. In order to facilitate learning, teachers need to develop future concepts by challenging the preconceptions that each child has (Johnston & Gray, 1999). Johnston (2005) reported that in order to help children develop scientifically, the teachers need to provide them with a variety of more child-centred experiences and exploratory play resources.

Taking all this research work into account, in order to help the children develop their concepts and conceptual understandings, it is essential to provide opportunities to make links between their own concepts and the accurate ones (Russell & Watt 1992). Such opportunities could be: making predictions, gathering evidence through observations, suggesting explanations based on their own interpretations of information etc. This way, children will be helped to develop more scientific concepts which will make sense and will be connected to their everyday lives (Russell & Watt 1992). It is important to remember that early-years children learn through trial and error and this takes time and patience (Johnston, 2005). Dewey agreed with this opinion and recognised that children learn better when offered varied activities because they have different types of intelligence and learning needs (Johnston, 2005).

However, Harlen (1996) argues that some teachers may avoid or not know when and how to introduce the scientific view of things and in what way, for the children to understand it. She implies that some teachers might be reluctant to give the children scientific explanations because they think that the children will not understand them and they fear that they will cause confusion in the children's minds. Some others may not do it because they are not sure either which implies that the teachers' own subject knowledge is important as well. As a result, the children may be left with their preconceptions when they could actually be exploring natural phenomena to construct their understandings.

4. 4. 1. Early-years teachers and constructivism

The construction of knowledge can be seen: 1) as an individual procedure, similar to what is called 'discovering learning', which means that the knowledge construction is a solely individual process and 2) as a social interaction process that goes further than personal empirical inquiry and from which learners will be given access to the knowledge system of science (Driver et al., 1994). This means that teachers need to give access to children/learners to physical experiences and to concepts and models of conventional science. This can be challenging for teachers who need to help children appreciate what they learn and be able to use this knowledge in different situations. The challenge is even greater when the science view that the teachers present is in conflict with the children's prior knowledge and preconceptions (ibid, 1994).

As it has already been mentioned, the overall goal of pre-primary and primary science education is to help children make sense of the phenomena and events in the world around them (Harlen & Qualter, 2004). Guest (2003) stated that the difficulty with scientific concepts is that they are often counter-intuitive and the complex understanding needs to be made layer upon layer. From that point of view, teaching cannot be viewed as the transmission of knowledge from enlightened to unenlightened. Giving the children facts that do not link to their own experiences will not make sense to them and it can also discourage them from making questions as they might think that they do not understand the answers (Guest, 2003). Thus, it is considered important for teachers to give the chance to children to use their own concepts by providing them with opportunities to express and investigate their concepts (Harlen & Qualter, 2004).

The children's own concepts result from their thinking and individual experience. Finding out what others think can result in developing more widely shared concepts. Douglas Barnes (cited in Harlen & Qualter, 2004) refers to this as 'co-constructing' concepts and helping each other to make sense of things. In simple terms, this refers to a group of people that 'put their heads together' and offer a better understanding than anyone trying to work things out alone. As a result, teachers should guide children and help them report their experiences to each other and then combine them with evidence to reach a shared result and understanding.

According to constructivism, teachers should give guidance and provide students with opportunities to test the adequacy of their current understandings as well as help children realise that investigating their concepts can help their understanding of their everyday experiences (Harlen & Qualter, 2004). Teachers should provide children with first-hand experiences and time to explore them and look at them closely because this kind of experiences can help children to understand, since they can see, feel and experience themselves. Harlen and Qualter (2004) noted how important it is for children to have experiences and evidence against which to judge the adequacy of their concepts. As they say, evidence may come from secondary sources but it is better because it is important for children to collect them on their own. The role of the teacher is to enter a dialogue with the children who are trying to understand the meaning of the material to be learned, and to help the child to refine their understanding until it corresponds to that of the teacher's (Atherton, 2009). Different children may need different experiences to comprehend the same concept and will advance to different levels of understanding (Hoover, 1996).

Developing the children's understanding in Natural Sciences has to start from the children's existing concepts. If learning is based on prior knowledge, then teachers must know and note the children's prior knowledge and provide learning environments that will develop contradictions between the learners' current understandings and the new experiences (Guest, 2003). As a result, it is necessary for teachers to look into the children's concepts and consider the implications of taking them into account when teaching. Finding out the children's concepts is important but being serious about taking them into account in teaching is even more important (Harlen & Qualter, 2004). This can be a challenge for teachers as they will not be able to assume that all children understand something in the same way.

The teacher's role is to develop the children's scientific concepts from their initial concepts rather than just tell them the correct ones. Harlen and Qualter (2004) referred to the following danger: a teacher that insists on the children 'learning' the correct concept may lead the children to retain their own concept, simply memorise the correct one but without really believing it and hold on to their own concepts in the way they make sense of the real phenomena around. Therefore, the teachers need to look at what concepts children have since these will reveal that the concepts are a product of the children's experiences (necessarily limited experience especially when referring to early-years children) and not childish fantasies. Harlen & Qualter (2004, p15) wisely wrote that "*The children have reasons for what they think and unless they are helped to have even better reasons for thinking differently and more scientifically, they will retain their own ideas*".

Furthermore, if children apply their current understandings to new situations in order to build new knowledge, then teachers have to engage children in the learning procedure and they have to bring the children's current understandings to the forefront (Hoover, 1996). If a child is able to perform in a problem-solving situation, meaningful learning should then occur because the child has constructed an interpretation of how things work using pre-existing structures. By creating a personal interpretation of external ideas and experiences, constructivism allows children the ability to understand how concepts can relate to each other and pre-existing knowledge (Thalasoulas, n. d). Teachers need to make sure that the learning experiences that they provide will incorporate problems that are important to children. Teachers may as well encourage group interaction, where the interplay among participants helps children to become explicit about their own understanding by comparing it to that of their peers.

Teachers should also remember that as new knowledge is actively built, time is needed to build it. Thus, they will need to provide sufficient time so that the children will have the opportunity to reflect upon their new experiences, how these experiences line up against current understandings, and it can also help teachers identify how a different understanding might provide children with an ‘incorrect’ concept (Hoover, 1996). They must be careful and not rush children from one experience to another because they will have little opportunity to “try out their developing ideas and build upon existing ones” (Johnston, 2005, p.3). It takes time for concepts to develop, and so, they are unlikely to be acquired if only encountered once in one particular context. New concepts are more likely to link with existing concepts and make sense as they are developed through a variety of different context and activities (Bradley, 1996).

Time is very important for a Natural Sciences lesson as sometimes children need more opportunities to develop their process skills. Teachers are responsible for ensuring the children’s development of investigative skills and they need to provide the children with opportunities for thinking about fair tests. This includes giving the children the chance to decide what to do, give them some ownership of their investigations and give them opportunities and time to develop their process skills like predicting and communicating a result (Harlen & Qualter, 2004). Teachers need to guide children through developing their planning skills and their reporting skills and should encourage their reflection on how they could improve their investigations.

The language used by teachers when teaching Natural Sciences is considered to be one of the major sources for children to develop preconceptions. Guest (2003) noted that one of the teachers' roles is to help children acquire the correct language. This includes, firstly, the acquisition of language which refer to words acquired through discourse in social interactions and are given meaning from the experiences they are associated with. Secondly, teachers should help children translate the word in the related context. In order to understand a word, children compare and contrast its meaning in relation to other situations in which they heard or used this word in their everyday lives. This process, although important, can be insufficient in developing a scientific understanding of the word. Therefore, teachers need to go beyond that and help children develop interpretations of the words that they use as many of them can be interpreted in different ways. There is an everyday meaning and a scientific meaning. If understanding the word means evolving from the everyday meaning to the scientific meaning, then it is necessary for teachers to provide experiences that will draw attention to the new, extended meaning of the word. The chance to compare and contrast is crucial here but always children's prior knowledge and maturation need to be taken into account, as well.

Last but not least comes the teachers' role when planning a Natural Sciences lesson. According to constructivism, teachers should plan a lesson based on what children have done previously and what concepts children have about the specific topic being planned. Each lesson planning needs to ensure progression in development of conceptual understanding and skills. It also needs to meet the requirements of the national curriculum (Harlen & Qualter, 2004). Teachers need to plan short-term, medium-term and long-term on what they will do with their children. They should also consider the questions that they might pose and prepare themselves with information about concepts that the children might have and with suggestions for activities from sources. Finally, the teachers' planning should include activities and question planning that will aim at accessing the concepts that the children have already formed about what will be investigated and ways to encourage children to use their process skills. Careful planning can ensure the right contexts and time for children to talk about their investigations and share their results and concepts which can lead to a better understanding (Harlen & Qualter, 2004).

As Psillos et al. (2003, p.12) pointed out "it is not possible to change what teachers usually do in the classroom without transforming their epistemology, their conceptions about how scientific knowledge is constructed, their views about science". Fortunately, teachers do not have to be engaged in the nuances and details of the epistemology of different authors as, in spite of their differences, there is a common basis that relates to how authors conceive the nature of science.

Authors like Popper, Kuhn, Toulmin, Lakatos, Feyerabend, Laudan and Giene (cited in Psillos et al., 2003) all agreed on some common views according to which teachers must be engaged in order to be informed and then able to organise children's learning as a (re)construction of scientific knowledge. Firstly, there is 'analytical vision', which refers to enhancing the necessary fragmentation and simplification of the studies and also neglecting unification efforts in order to construct wider bodies of knowledge. Secondly, there is 'accumulative vision', which refers to the scientific knowledge appearing as the result of a linear development, ignoring crisis and deep reconstructing. Then, 'individualistic and elastic view' is the one that considers science to appear as the activity of isolated 'great scientists' who ignore the roles of co-operative work and interactions between different research teams. There is no special effort aiming to make science meaningful and accessible. On the contrary, science is presented as a domain reserved for specially gifted minorities, transmitting poor expectations to most children and falling into ethnic, social and sexual discriminations. Finally, the 'socially natural view' considers science as something elaborated in 'ivory towers', forgetting the complex STS relationships and the importance of collective decision-making on societal issues related to science and technology. Teachers need to be given the opportunity to discuss such possible deformations to the nature of science, transmitted by science teaching (Kallery & Psillos, 2001; Psillos et al., 2003).

4. 4. 2. Previous Research Focusing on Teachers

The Primary Space (Science Processes and Concept Exploration) Project (Russell & Watt, 1992) worked with teachers to find out about the children's understanding. It examined the concept areas covered by the national curriculum. Six schools were involved and twelve teachers participated in the Project work. The teachers' selection was not based on their background experience in science. In order to prepare them for Project work, the teachers were asked to attend meetings during the school day as well as meet after school at the research team's offices (Russell & Watt, 1992). All the children in the classes of the participating teachers were involved to some extent. A random sample of children was interviewed from each class. They described their sample as balanced for age, sex and achievement. There was also a third measure, which was the teacher's subjective rating about whether a child achieved high, middle or low overall school performance (ibid, 1992).

The specific research was constructivist in orientation, based on the theory that the children actively construct their own understanding of how the world works. The results showed that the necessity for ensuring scientific rigor in the children's investigations was not familiar to some teachers and this sometimes "led to children performing tests which confirmed rather than challenge their original notions" (Russell & Watt, 1992, p.57). However, the teachers' awareness of the importance of science process skills for conceptual development was a very positive outcome of the Project. They found that the children's concepts are influenced by their own understanding of direct experiences and, also, by their interpretation of socially transmitted concepts (Russell & Watt, 1992). This is very important because knowledge of the children's starting points is invaluable to teachers and curriculum developers since it provides insight as to where teaching should begin.

Furthermore, Pine, et al. (2001) researched the children's preconceptions in primary science and their teachers' views. More specifically, they developed a questionnaire aiming at identifying the children's naïve theories about topics within the Key Stage 1 curriculum in the United Kingdom. Copies of that questionnaire were sent to 200 randomly selected primary schools in four education authorities together with a letter to the headteacher which was asking for the co-operation of the school and requesting for the questionnaire to be filled in by a teacher or teachers who had been teaching Key Stage 1 Science for at least 1 year. Eighty one schools (40%) replied with a total of one hundred twenty-two teachers. The first set of questions “concerned the science topics which children had difficulty with and the types of naïve ideas exhibited by children” and, following, the teachers were asked to answer questions according to their own experience about the children’s pre-existing knowledge and how this affects learning (Pine, et al., 2001, p.84).

This research showed that teachers usually thought that it was important for them to know what children already know about the topic taught and they thought that they had a good idea of what the children already knew. In addition, teachers did not think that the children’s preconceptions are helpful in bringing about new understanding but agreed that preconceptions can be helpful when known because they can be used as starting points for discussions. Most teachers expressed the opinion that it is very difficult for a child to overcome its preconceptions. Specifically, one teacher said “Some (children) find it hard to change their ideas” and another pointed out “They have to investigate but they sometimes still think they are right” (Pine, et al., 2001, p.90).

For Pine et al. (2001) there was an ambiguity about the role that preconceptions play in the classroom. One implication of this is that teaching strategies may need to be carefully employed if preconceptions are to have a positive rather than a negative effect (Pine et al., 2001). The teachers themselves described a range of methods used to find out the children’s prior knowledge like discussion, past records, brain storming, questioning, testing and predicting. However, this cannot tell us if finding out what the children know also involves searching for their correct concepts about the topic, or active probing for preconceptions. The fact that most teachers said that preconceptions do not affect the children's ability to understand a new concept may imply that teachers think that preconceptions might get in the way of the teaching process but it is best to ignore them something which was also reflected from the teaching practice (Pine et al., 2001).

The results from this research are very important because they indicate that preconceptions play a very important role in the acquisition of new concepts and, also, that only if teachers know about the children's preconceptions will the process of change be helped (Pine et al., 2001). The specific research revealed some of the preconceptions teachers believe the children to have and the many false science beliefs relating to Key Stage 1 curriculum topics. It also confirmed the view that children do not enter classrooms with empty minds but with a lot of concepts, about the world based on their everyday experiences, although these concepts may sometimes be incorrect (Pine et al., 2001). Their conclusion was that children have a lot of preconceptions about science topics and these preconceptions are of considerable importance and cannot be ignored in the learning process since they are "foundations upon which knowledge is built" (Pine et al., 2001, p.93). Therefore, if teachers want to accomplish conceptual change in science, they need to place as much emphasis on the children's incorrect concepts as on their correct ones.

Another research from Kallery (2001) focused on Greek early-years teachers' attitudes to astrology. The study aimed to prove if teachers were able to distinguish between astronomy as science and astrology as 'pseudo-science'.

According to Kallery (2001), 'pseudo-science', which literally means false science, is still common in modern society and refers to those concepts that have some scientific validity but are characterised by false reasoning or lack of empirical support, which is very similar to alternative concepts. A very common example of 'pseudo-science' is astrology, which has become very popular especially in western societies and has become a big business. There is a general agreement that the specific problem is so big that it should be addressed by the educational system itself, which indicates that teachers themselves need to make a special effort to speak out against 'pseudo-science'. Thus, a teacher's attitudes and thoughts are more serious when it comes to young children who can be very easily influenced by their teacher's views. Kallery (2001) points out that children experience science in an educational environment for the first time at the ages between four (4) and six (6) and at this time science education has to help them eliminate superstition and the abject mystification of technology and natural phenomena.

One-hundred and three (103) early-years teachers participated in this study and the results indicated that sixty per cent (60%) of the teachers subscribed more or less the astrological principles and an equally large percentage (59%) viewed both astronomy and astrology as scientific. The results of this study can be considered as significant ($P<0.01$). Kallery's (2001) findings indicate the need for an attempt to deprogramme the teacher's beliefs towards astrology as these beliefs are resistant to change. Other researches attempted to change these beliefs for prospective elementary teachers and found that it can be possible as the response of the students who studied to become teachers was positive (Kallery, 2001).

Valanides (2000) researched primary student teachers' understanding of the particulate nature of matter and its transformations during dissolving. He used one-to-one interviews and a sample of twenty female primary student teachers studying at the University of Cyprus. The student teachers were asked to describe changes in macroscopic (colour, taste etc.) and microscopic (movement of molecules) properties of matter when dissolving salt or sugar in water, when mixing water and alcohol, or when filtering or heating the respective water solutions. This understanding is essential to grasping the nature and the importance of everyday phenomena such as the process of dissolution of substances.

When analysing his research results, Valanides (2000) found that the majority of the primary student teachers showed perceptual rather than conceptual understanding of the particulate nature of matter and had difficulties in relating the macroscopic changes that they observed to the invisible microscopic changes of molecular events. The student teachers believed that molecules share observable properties of matter and combine together to give new molecules, without realising the changes in the structure and the properties of matter or without being able to distinguish physical from chemical changes. These results indicate that the constitution of matter is not sufficiently understood by student teachers and that the teaching material and instructional interventions based on conceptual change should be designed and implemented both for the teachers' pre-service and in-service training, to avoid having teachers with alternative concepts teaching children in the primary classrooms (Valanides, 2000).

Chapter 5: Research Questions

5. 1. Why Research in this Field is needed

Despite all the previous research, there are some people that might argue that such concepts can be the result of incorrect observations or illogical thoughts and would question the need to investigate them at all as they believe that they are wrong and, just like the attention seeking misbehaviour of a naughty child, they can be best extinguished by lack of reinforcement (Driver & Easley, 1978). However, Schmidt (1997) pointed out that ignoring alternative concepts and hoping that children will overcome them on their own is unfair. Some children fail to learn concepts when the subject matter material is at a level that does now match the developmental learning stage of the child or the child may hold on to tenacious alternative conceptions that were not identified before the instruction and considered during the stages of instruction (M.D.E.S.E, 2005).

Additionally, children's concepts do not always evolve as quickly as the rate of concept presentation in textbooks or in teacher-designed units of instruction. In addition, the language used by the teachers and in textbooks can confuse children, especially when their own everyday experiences are not taken into account by the teacher (M.D.E.S.E., 2005). Children's beliefs result from personal experiences, intuition and "common sense", which can lead children to form their own concepts and models, often well before formal instruction, and which often contradict what children read or listen by their teachers. Even with instruction, it is often difficult for children to give up these concepts, or they may revert back to them later even though they may have 'learned' the correct concepts in class.

As a consequence, it is of great importance to investigate the area of children's alternative concepts since when knowing children's alternative concepts teachers can plan lessons to clear them up (Schmidt, 1997). If, with the use of appropriate tasks, the real difficulties faced by children can be detected, then it is possible to orient the processes of the communication which permit children to overcome their difficulties (Ravanis & Bagakis, 1998). Instruction which fails to identify which the children's initial concepts are can leave children unchanged, whereas curriculum, instruction and assessment are significantly improved when teachers are aware of the development considerations and the research findings on commonly held conceptions (M.D.E.S.E, 2005).

5. 2. Research Questions

It would be unreasonable to believe that one teaching method or approach can always work better than another, regardless of the learners or the contexts of the teaching or the qualities of the teacher involved. What seems to be reasonable is to look for ways to improve on current practice, without necessarily believing that there is a single, best way to do it (Psillos et al., 2003). Research is not about telling us what we ought to do, but it can help us to learn how to do it effectively. As Psillos et al. (2003) highlighted "The role or research is not only to tell us 'what works'. Some of the most valuable research studies have been ones that made people aware of problems in current practices" and this is very important for this study.

However, there is no recipe for correct teaching and we cannot say "let's consider children's previous concepts and preconceptions, let's provoke cognitive conflicts in them and let's introduce the correct concepts". What we can do is raise awareness about the need, among other things, for teachers to consider children's preconceptions and ways of reasoning, overcoming conceptual reductions and enriching conceptual change proposals.

Defining the research questions is one of the most important steps to be taken in this research study. As Yin (2003) described, one way of formulating the research questions is to review the literature review on the topic. The following research questions were developed after investigating previous research to develop sharper and more insightful questions about the topic.

Main Question: How do teachers respond to young children's preconceptions in Natural Sciences?

Sub-questions: **1)** Do early-years teachers identify children's preconceptions? **2)** If yes, how? and **3)** Why do they identify preconceptions? **4)** How do early-years teachers work with children's preconceptions during a Natural Sciences lesson? **5)** What kind of training do early-years teachers receive about children's preconceptions?

Answering the above research questions can inform practice by providing the kinds of insights that enable us to see the familiar in a new way, by sharpening thinking, by directing attention to important issues (such as children's preconceptions), by clarifying problems (such as the one of ignoring children's preconceptions), by challenging established views, encouraging debate and stimulating curiosity (Psillos et al., 2003). The reader should keep in mind that the whole research design and research methodology aim at answering the above questions.

6. Research Methodology

6. 1. Educational Research Methods

This section will demonstrate that the choice of the research data collection methods is a very important decision and that careful consideration has been given to those most appropriate to address the research questions for this research. The distinction between methods is not always clear as they can sometimes overlap. As defined by Yin (2009), the most important condition for differentiation among different research methods is to identify the type of research questions asked. 'What' questions lead to exploratory studies and the aim of such research would be to develop significant hypotheses and propositions for further inquiry. In addition, 'what' and 'who' questions are likely to favour survey methods or archival analysis when the goal of the research would be to describe the prevalence or occurrence of a phenomenon or when it is to be predictive about certain outcomes. Finally, 'how' and 'why' questions usually lead to explanatory studies and probably to the use of case studies, histories or experiments. As Yin (2003, p.5) pointed out "such questions deal with operational links needing to be traced over time, rather than mere frequencies on incidence".

The questions in this research are 'how' questions, as the main question is 'How do teachers respond to young children's preconceptions in Natural Sciences?' In some cases 'how' questions can lead to 'why' questions which are also asked in this research. Based on that, this study is a combination of an exploratory/explanatory study as it has both characteristics. This means that this study does not only aim at investigating what is happening and how, but it also tries to find some explanations about why things happen in a specific way.

Researches similar to this one usually use one of the following: a case study, histories or experiments. Moreover, some of them use qualitative research methods and some others use quantitative research methods. As a result, there is a need to investigate the qualitative and quantitative research methods in order to define which is the most suitable to use for this research.

6. 1. 1. Investigating Qualitative and Quantitative Methods

Following qualitative research methods can enable researchers to learn firsthand about the social world under investigation by means of involvement and participation in that world through a focus upon what individual actors say and do (Hitchcock & Hughes, 1989). Qualitative research as opposed to quantitative has the considerable advantage of drawing the research participants and the researcher closer together. Recognising that educational schemes are differently interpreted by the different participants, the aim is to deconstruct the educational event that involves their views, i.e. present the participants' construct and narrate their reality (Seale, 1999).

When claiming that the objective of the research is to try to gain understandings, the participation of the people affected most by a social situation is essential. Qualitative research is not, therefore, a unified set of methodologies. However, all qualitative research seeks interpretation and critical engagement with the situation under investigation (Tesch, 1990).

On the other hand, quantitative methods indicate the collections of numeric data that are analysed using methods based on mathematics and statistics in particular (Muijs, 2004). Wiersma (1995) added that quantitative research is the research that describes phenomena in numbers and measures instead of words, which is what qualitative research describes. Quantitative researchers place great value on outcomes and products. It is a powerful research method and is often associated with large-scale researches, but can also serve smaller scale investigations like case studies, action research or experiments (Cohen, Manion and Morrison, 2007).

There are quantitative studies which are detailed and involve collecting lots of numeric data. Yet, in detailed quantitative research, the data themselves tend to both shape and limit the analysis. Generalising tends to be a fairly straightforward endeavour in most quantitative research (Cohen, Manion and Morrison, 2007). When collecting the same variable from everyone in a sample, all that is needed to do to generalise the sample as a whole is to compute some aggregate statistic like a mean or median.

Qualitative research methods usually excel at generating information that is very detailed, as it can address the 'why' and 'how' questions rather than the 'what' from qualitative data. However, things are more difficult when generalising qualitative research. The data are more 'raw' and are seldom pre-categorised. Consequently, a lot of preparation needs to be made to organise all that unprocessed detail (Trochim, 2006); and there are a lot of different ways this can be accomplished. The detail in most qualitative research is both a blessing and a curse. On the positive side, it enables the research to describe the phenomena of interest in great detail. On the negative side, when that kind of detail is collected, it is very hard to determine what the generalisable themes may be. Some qualitative researchers are not concerned about generalising since their aim is to generate rich descriptions of their phenomena (Trochim, 2006).

Consideration of the above information led to the thought of mixing qualitative research with quantitative research methods. Quantitative research excels at summarising large amounts of data and reaching generalisations based on statistical projections (Trochim, 2006). Qualitative research excels at 'telling the story' from the participant's viewpoint, providing the rich descriptive detail that sets quantitative results into their human context. As a result, the next step is to investigate 'mixed methods'.

6. 1. 2. Mixed Methods Research

As noted by Johnson and Christensen (2008, p.51), the use of mixed methods "helps to improve the quality of research because the different research methods have different strengths and different weaknesses". A researcher can move between two or more research methods, depending on what is the aim of the specific research. A combination of methods can create more clarity in regard to what is true knowledge and can also help to correct the biases that each method can provide when used alone (Chih Lin, 1998).

Mixed methods research refers to a research strategy which utilises more than one type of research method which can be a combination of qualitative or a combination of quantitative research methods or a combination of both. According to Brannen (2005), the term 'mixed methods' also means working with different types of data. The fundamental principle of mixed methods research is that we can learn more about a topic when the strengths of qualitative research are combined with the strengths of quantitative research and at the same time the weaknesses of both methods compensate (Johnson & Onwuegbuzie, 2004).

Nevertheless, it is not considered that mixed methods research can offer a recipe for the ideal methodology and the methods for a research design, but work needs to be done in order to combine the methods in a way that will achieve complementary strengths and overlapping weaknesses (Punch, 2009). The choice of specific methods that will be combined is subject to the kind of knowledge that the research seeks to generate (Brannen, 2005).

Taking into account the above, this research considers that the use of different kinds of methods would promote the collection of different kinds of data that can help to give correct answers to the research questions. However, a general methodology needs to be followed in order to be able to organise all the data collection methods that will be used. The following part helps to understand why the use of a case study is considered to be appropriate for this study[3].

6. 1. 3. The Selected Research Methodology

As Doug Roberts (cited in Psillos et al., 2003, p.5) firmly reported *"There can be no such thing as a science-like 'theory of science education', that is, an explanatory theory with predictive probability. The reason is simple: The events of science education are unique (and) non-replicable"*. Bearing this in mind, it would not be reasonable to look for just one method that would work better than another, especially when researching science education.

[3] It was considered to be more suitable to use the term 'study' from this point onwards instead of 'research' as the research approach followed is a case study.

When thinking about the complexity of researching early years' science education, the nature of this study and the research questions, the use of a case study which involves a selection of both qualitative and quantitative methods is thought to be helpful. According to Trochim (2006), a case study is a research methodology that facilitates the combination of different data collection methods, as there is no single way to conduct a case study; case studies can include both qualitative and quantitative methods of data collection.

As a result, this study fills in the 'gap' between these approaches by being aware of the significant differences and limitations between them. The use of a case study helps to accomplish this, as case studies have the unique ability of dealing with a full variety of evidence, documents, interviews and observations (Yin, 2009). Different instruments, which will be described below, are combined and the advantages of the one help in overcoming the limitations of the other. Brown & Dowlin (1998, p.72) agreed with this when they said that "the advantages of the use of interviews mirror the limitations of questionnaires...similarly, the limitations of the use of interviews mirror the advantages of questionnaires". In the same way, the use of questionnaires, interviews, observations and focus groups can limit the disadvantages that each instrument might have when being used on its own.

6. 2. The Nature of this Case Study

This study is based on the opinion that better understanding of the whole can be gained by focusing on a key part (Gerring, 2007). As Robson (2002) explains, a case study includes the development of detailed, intensive knowledge about a single ‘case’ or a number of small related cases. In other words, a case study is an intensive study of a specific individual or specific context. For instance, Freud developed case studies of several individuals as the basis for the theory of psychoanalysis and Piaget did case studies of children to study developmental phases (Trochim, 2006).

As it has already been mentioned, case studies are preferred when ‘how’ or ‘why’ questions are posed, when the researcher has little control over events, and when the focus is on a contemporary phenomenon within some real-education context (Yin, 2003). In-depth knowledge of an individual example (or a number of individual examples) can be more helpful than fleeting knowledge about larger number of examples (Gerring, 2007).

In addition, a case study can allow a researcher to retain the holistic and meaningful characteristics of real-education events. Indeed, a case study can enable the researcher to understand how ideas and abstract principles can fit together, which is important for this study. As Bell (1999) noticed, case studies are particularly appropriate for individual researchers as they give an opportunity for one aspect of a problem to be studied in some depth within a limited time-scale and give the opportunity to the study to engage more than one methods of data collection, which is also important for this study.

Stenhouse (cited in Bassey, 1999) identified ‘educational case study’ as the study that aims to enrich the thinking and communication of educators either by the improvement and development of educational theory or by alteration of prudence through regular and reflective documentation of evidence. Case studies can be exploratory, descriptive or explanatory. As Yin (2003) explained in a few words, an explanatory case study aims at defining the questions and hypotheses of a subsequent study. Such a study might also include attempts to determine theory by directly observing a phenomenon in its 'raw' form. A descriptive case study presents a complete description of a phenomenon within its contexts. Finally, an explanatory case study presents data bearing on cause-effect relationships explaining which one produces which effects.

Case studies can also have limitations, as well, especially when the researcher is not careful. For example, they have been accused for lack of rigor and have been described as 'sloppy' investigations which follow systematic procedures or allow equivocal evidence or biased views to influence the direction of the findings and conclusions. But bias can also enter any other kind of strategy. They have also been accused for providing little basis for scientific generalisation.

Stenhouse (cited in Bassey, 1999) and Yin (2003) both talked about generalisation. 'Predictive generalisation' for Stenhouse, or else 'statistical generalisation' for Yin, arise from the study of samples and refer to the form in which data are accumulated in the sciences. On the other hand, 'retrospective generalisation' for Stenhouse, or else 'analytic generalisation' for Yin, arise from the analysis of case studies and refer to the form in which data are accumulated in history. As Yin (2003) explained, case studies results can be generalised to theoretical propositions instead of populations or universes. This is because a case study aims at expanding and generalising theories (analytic generalisation) and not at enumerating frequencies (statistical generalisation).

The above information helped in understanding the importance for this study to take into account and understanding the participants' actions and observations in regard to the research subject of interest, their impressions, irritations, feelings and so on. This case study recognises that all these should and have become data and have been documented as described by Flick (2007). Considering and including them is essential in order to obtain insights of the investigated situation and to answer the research questions.

As it has already been mentioned, the specific study has characteristics from both exploratory and explanatory case studies. It does not only aim at describing what happens in an early years classroom during a Natural Sciences lesson but it also aims at understanding the teachers participating and how each one of them deals with children's preconceptions. The term 'explanatory' has been chosen for this case study as it implies going in more depth in order to investigate the reasons why something is happening. This can lead to a further understanding of early years' Natural Sciences lessons in Cyprus and how teachers usually deal with children's preconceptions. Considering that this is a rather new topic of investigation for Cyprus, as it has received little attention so far, the main aim is to understand and describe what is happening and define further questions and hypotheses that later studies can further examine, like what kinds of cause-effect relationships exist.

The use of a case study can introduce bias into the research design. This study acknowledges that I need to be precise about my own biases. Flick (2007) added that knowing the social reality and developing our understandings about education can only be secured when all the views and perspectives which are fundamental to the actions we want to explain are considered. Thus, personal bias has been considered during the research process.

As a result, using a case study might make it difficult to generalise the results, but it does not make it impossible. The use of triangulation, which will be further explained later on, and the use of the questionnaire, in addition to the interviews, the observations and the focus groups have helped in regard to this. Even thought the aim of this study, as it has already been stated, is mainly to understand 'what is happening', generalising the results of a study like this is also important (Ercikan & Roth, 2009).

Finally, a case study can last too long when the researcher is not careful and result in massive and unreliable documents. This case study considers the fact that good case studies can be difficult to do. I was aware that in order to succeed, a lot of organisation and careful planning was needed. Case studies do not need to be extensive narrations nor need to take a long time (Yin, 2003). Good case studies are patient, reflective, willing to see another view of the case and this is the nature of this case study, as well.

6. 2. 1. The Research Design

As it has already been explained, this is an explanatory case study which leads to having an explanatory design that will help mix the different methods of data collection better. The explanatory design is a two-phase mixed-method design where the researcher uses qualitative data to help explain initial quantitative results (Punch, 2009). As a result, the specific study was conducted in two phases. The first phase included the collection of quantitative data through the use of questionnaires. The second phase included the collection of qualitative data through the use of observations, interviews, focus groups and document analysis.

The first phase quantitative results helped to guide the selection of sub-samples for the follow up in-depth qualitative investigation in the second phase. This type of design is identified by Punch (2009) as having wide potential applicability in education research.

In addition, a research design can also be a fixed design or a flexible design. When using the fixed design, the researcher knows exactly what she is doing before collecting the data and all the data is collected before starting to analyse it, whereas the flexible design is about developing the design through interaction with whatever the researcher is studying and the data collection and analysis are intertwined.

Thus, the research design for this study was a flexible explanatory design and it was approached through a case study. This case study used unique examples of real people (teachers) in real situations, thus making it possible to have a better understanding of how they respond to children's preconceptions in science. Typically, the details of this design emerged during data collection and analysis. The goal was to design a good case study and to collect present data which to analyse fairly.

This implies that no hypothesis was made for this study in advance and the research was open to any outcome, which helped eliminate biases. The next section will give some more information on this and on how triangulation, validity and reliability have been achieved for this study.

6. 2. 1. a. Triangulation

A flexible explanatory design that uses a case study which mixes a selection of different data collection methods inevitably leads to triangulation. As Hitchcock and Hughes (1989) explained, the use of more than one method of data collection within a single study is called ‘triangulation’. Triangulation encourages flexibility and can add some depth to the analysis and can potentially increase validity of the data and the analyses made of them.

Triangulation aims at increasing the credibility and validity of the research’s results. Several scholars have aimed to define triangulation throughout the years. For example, Cohen and Manion (1986) defined triangulation as the attempt to explain more fully the richness and complexity of human behaviour by studying it from more than one standpoints. Similarly, for O’Donoghue and Punch (2003), triangulation is a method of cross-checking data from multiple sources to search for regularities in the research data. There are four basic types of triangulation: 1) Data triangulation, which involves time, space and persons, 2) Investigator triangulation, which involves multiple researchers in an investigation, 3) Theory triangulation, which involves using more than one theoretical scheme in the interpretation of the phenomenon, and 4) Methodological triangulation, which involves using more than one method to gather data, such as interviews, observations, questionnaires, and documents.

Triangulating questionnaires with observation, interviews, focus groups and document analysis has really been helpful for this study as it helped to obtain complementary quantitative and qualitative data on the same topic, bringing together the strengths of the two approaches (qualitative and quantitative) and the different data collection methods. For example, focus groups are useful to triangulate with more traditional forms of interviewing, as there are several issues that need to be addressed and can lead to biases when running focus groups on their own. For instance, when deciding issues like the number of focus groups to be made or the number of participants, using more than one instruments makes the whole procedure easier.

Using a multi-method case study approach, which led to triangulating the data collected, had advantages, such as a variety of different sources of data which increased reliability and validity. (This will be analysed further below). However, it entailed some dangers. I needed to be very careful to make sure that the data elicited by the different techniques were actually comparable (Hitchcock & Hughes, 1989). In other words, there are a lot of different kinds of data and one data source might not be able to be used totally without problems to validate another source of data. The specific study employed questionnaires, observations, interviews, focus groups and the analysis of a public document. Although this form of triangulation is able to promote such problems, it was avoided thanks to careful planning and organisation of the data. The instruments used provided qualitative and quantitative data which were then merged through the interpretation-stage results.

6. 2. 1. b. Reliability and Validity

Reliability is thought to be a central concept in measurement and it mostly refers to consistency: consistency over time and internal consistency. Consistency over time refers to the stability of a measurement instrument which asks: when the same instrument is given to the same people, under the same circumstances but at a different time, to what extent would we get the same response/scores (Punch, 2009). Internal consistency refers to the extent to which the instruments used are consistent with each other and work towards the same direction. This study considers reliability as a fit between what has been recorded as data and what is actually being researched.

According to Denzin and Lincoln (cited in Cohen, Manion & Morrison, 2007) there are different ways to address reliability. One of them is known as 'stability of observations' and it is about whether I would have made the same observations and interpretation if the observations had taken place at a different time or in a different place. Another way to address reliability is by checking whether I would have made the same observations and interpretations of what has been observed if I had paid attention to other phenomena during the observation. This is known as 'parallel form'. Finally, there is also 'inter-rater' reliability, which refers to whether another observer with the same theoretical background and observations of the same phenomena would have interpreted them in the same way as I have.

The use of different instruments to measure the same thing helped to ensure the reliability of this study providing "two different, but equivalent, forms of an instrument to the same group of individuals at the same time" (Fraenkel & Wallen, 2006, p.165). Triangulation of the data, through comments noted by participants on the questionnaire and through interviews of a sample population within the questionnaire participants, in addition to the notes taken during the observations, helped to maximise reliability of the instruments used.

Validity, on the other hand, refers to the extent to which a study truly reflects the specific concept that the researcher is attempting to measure. Thus, validity is concerned with the study's success in measuring what the researchers set out to measure, whereas reliability is concerned with the correctness of the actual measuring instrument or procedure. In other words, validity refers to ensuring that the answer to ‘Are you measuring what you think you are measuring?’ is ‘Yes’.

There are several kinds of validity, but it is not appropriate to explain all different kinds here. For this study, it is important to acknowledge and ensure construct validity, internal validity, conclusion validity and external validity. Construct validity accurately represents reality and occurs when the theoretical constructs of cause and effect accurately represent the real-world situations they are intended to model. Moreover, internal validity occurs when it can be concluded that there is a causal relationship between the variables studied. A danger is that changes might be caused by other factors. Internal validity is related to the design of the experiment, such as in the use of random sample selection and assignment of treatment. Both the use of triangulation and the careful planning of this case study have helped to check and ensure construct and internal validity.

In addition, conclusion validity occurs when you can conclude that there is a relationship of some kind between the two variables examined. This may be positive or negative correlation. The use of the questionnaires has helped to identify these relationships, which are further explained later. Finally, external validity occurs when the causal relationship discovered can be generalised to other people, times and contexts. The correct and careful sampling selection allows generalisation and, hence, gives external validity.

Validity can be ascertained by examining the sources of invalidity. Kvale (2007) pointed out that a valid argument is sound, well-grounded, justifiable, strong and convincing. In order to collect valid data, I asked the participants to justify their answers by explaining in more detail or by giving examples. In addition, the pilot research helped to reassure that the questions asked would produce data that would answer the research questions.

It is also important to recognise that the amount of direction provided by the researcher influences the types and the quality of the data obtained from the participants (Stewart, Shamdasani & Rook, 2006). Thus, as the moderator-researcher, I needed to be very careful in regard to that. For example, during the focus groups, the participants were encouraged to stimulate each other to articulate their views. Such issues of reliability, which pertain to the consistency of the research findings, refer to all phases of conducting the research, transcribing and analysing the data. For example, when they are not a deliberate part of an interviewing technique, leading questions may inadvertently influence the answers. Increasing the reliability of the interview findings has been desirable in order to counteract haphazard subjectivity and to ensure that I have avoided the use of any kind of leading questions at all times.

The lack of standardisation because of the semi-structured plan for the interviews, the focus groups and the observations may raise concerns about reliability and biases. Bell (1999) agrees that interviewing is a highly subjective technique and, therefore, there is always the danger of bias. It can be difficult to see how bias can be avoided completely, but awareness of the problem along with constant self-control can always help. The use of the criteria that Kvale (2007) suggested has helped me to check the quality of the interviews. These criteria refer to the extent of spontaneous, rich and relevant answers from the interviewee, the degree to which the interviewer follows up and clarifies the meaning of the relevant aspect of the answers and the length of the interviewer's questions and the interviewee's answers (the shorter the questions I made and the longer the participant's answers, the better).

Furthermore, designing an observation schedule that was piloted and then used during each one of the observations helped me to be consistent and look for specific things during the observations. The same thing has happened with the questionnaire as it was reviewed by three different individuals with different perspectives and piloted on a significant sample population[4] prior to distribution. Finally, the questions used were selected very carefully in order to avoid confusing the participants and ensuring the validity of their answers.

In addition, the fact that all the participants knew from the first moment that the research would protect their anonymity encouraged them to talk freely and express their opinion without any fears. They were ensured that everything that they said would be confidential and they were also informed about their right to withdraw at any moment, with or without a reason. This empowered them to feel confident and express themselves. Moreover, the teachers that participated in the focus groups looked very comfortable with each other and it is possible that

[4] The questionnaire was completed by fifteen teachers in order to be piloted prior to distribution.

the small number of the group and the friendly environment helped them to feel free and express their opinions.

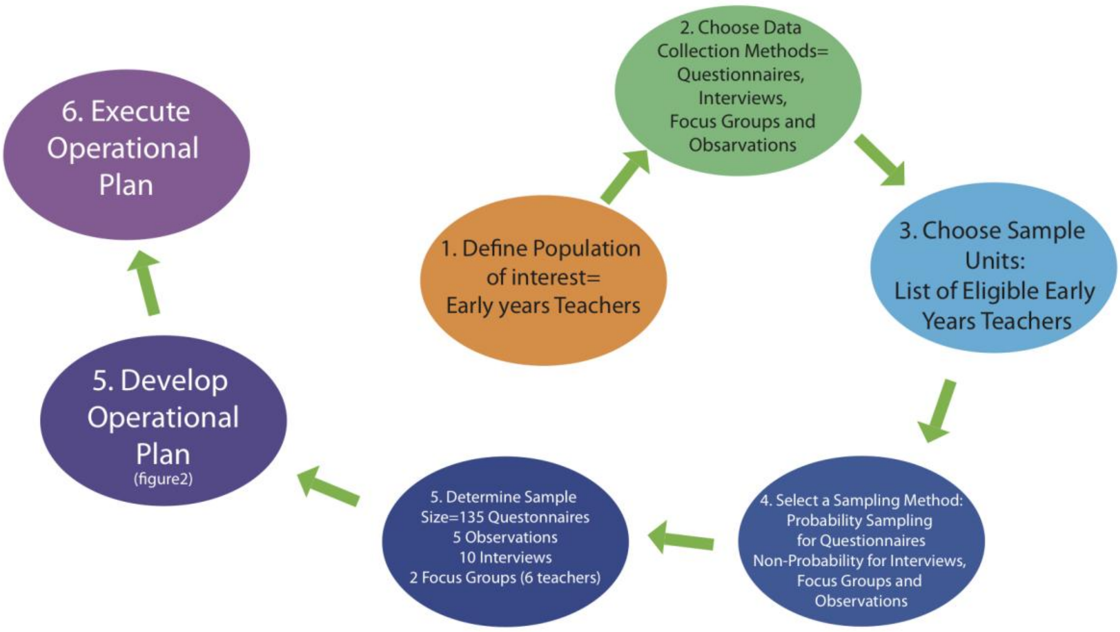
Finally, during the transcription and the coding of the responses, I have been very careful to keep everything as it was said by the participants and in the exact way that everything happened. Of course, translating everything from Greek to English has been quite difficult as I ran the risk to change the meaning in some cases because of the difference between the two languages, but I have tried my best to avoid that as much as possible. In many cases, I have even asked people to help me in order to keep everything as real as possible.

It is also worth noting that piloting the instruments used has not only helped me to practise, but also to ensure that they are valid and reliable instruments that have all the necessary characteristics to provide valid and reliable data and results. As Robson (2002) commented, a good researcher needs skills that do not occur just by reading them. It requires practise and it is better to practise them under ‘low risk’ conditions where it will be possible to receive feedback on the performance. This is what a pilot study is used for. Using the methods that will be used with real persons is a good way to check their utility. More details about piloting each instrument will be given below.

6. 2. 1. c. Sample and Participants

For this study, the research design includes a stage in which some members of a given population were selected as representatives of the entire. This has helped to get information from a larger population at minimal cost, maximum speed, at increased accuracy and using enhanced tools (Merriam, 1998). The selected members are called the 'research sample'. According to the research design for this study, firstly, the sample for the questionnaire was selected and the questionnaire results guided the selection of sub-samples to follow up in depth qualitative investigation. Thus, the sample for the observations, the interviews and the focus groups was selected based on the questionnaire and key informants' interviews results.

Figure 7: Steps Followed in Developing the Sample Plan (based on Steps in Developing a Sample Plan, *2011)*



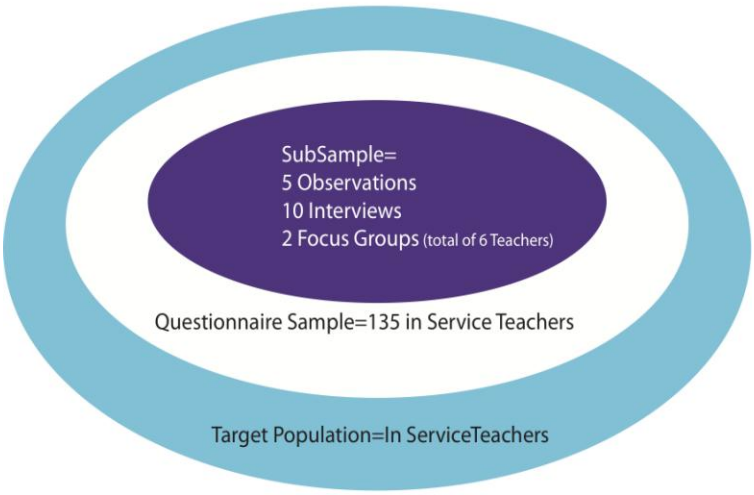
Firstly, as the figure shows, the research population is targeted and it includes specifying the characteristics of those whose information is needed and defining the characteristics of those who should be excluded. In this case, the research population refers to all teachers working in early years schools situated in Southern Cyprus. The next step is to choose the data collection methods and the impacts for the sampling process and, then, choose the sampling frame, which refers to identifying a list of elements or members from which the units to be sampled will be selected. Then, the sampling method is selected based on the research questions/objectives of this study, the available financial resources, the data collection methods and the time limitations.

The next step is to determine the sample size which will be chosen in order to be representative according to the size of the whole population. Then, the operational procedures for selecting the sample elements are developed. A list has been developed of all eligible sampling units with enough information to contact them successfully. At this stage it is specified whether a probability or non-probability sample has been used. For this study, a probability systematic sampling is used for the questionnaire since a random sample is selected from a list. This means that the members of the population have the same chance (probability) to be selected into the sample. (A non-probability sample would mean that the chances of selecting members from the population into the sample would be uneven).

Specifically, one out of every ten schools is selected with the use of a catalogue which includes all early-years and primary schools of Southern Cyprus. This sampling method is much more efficient than simple random sampling as there are approximately known and equal chances of selection, and it offers efficiency as there is no need to designate every population member. It is also less expensive and faster than other methods. However, there is a small loss in sampling precision. Finally, the sampling plan is executed. This step includes an adequate check of specified procedures.

For this study, the questionnaire results indicate that the target population is mostly formulated by white female teachers who have graduated from the Pedagogical Academy and from the University of Cyprus. Thus, the sub-sample for the second phase of data collection has been selected in order to keep these characteristics of the population. For this reason, the probability stratified sampling method is used, as the questionnaire results have helped me to realise that the answers to the research question are likely to vary among sub-groups. This method helps to separate the population into two different strata: one with teachers who have graduated from the Pedagogical Academy and one with teachers who have graduated from the University of Cyprus. As a result, a sample has been taken from each stratum.. The figure below shows how the sub-sample has been selected from the questionnaire sample.

Tables & Figures 8: The sub-sample selection for the questionnaire of this study



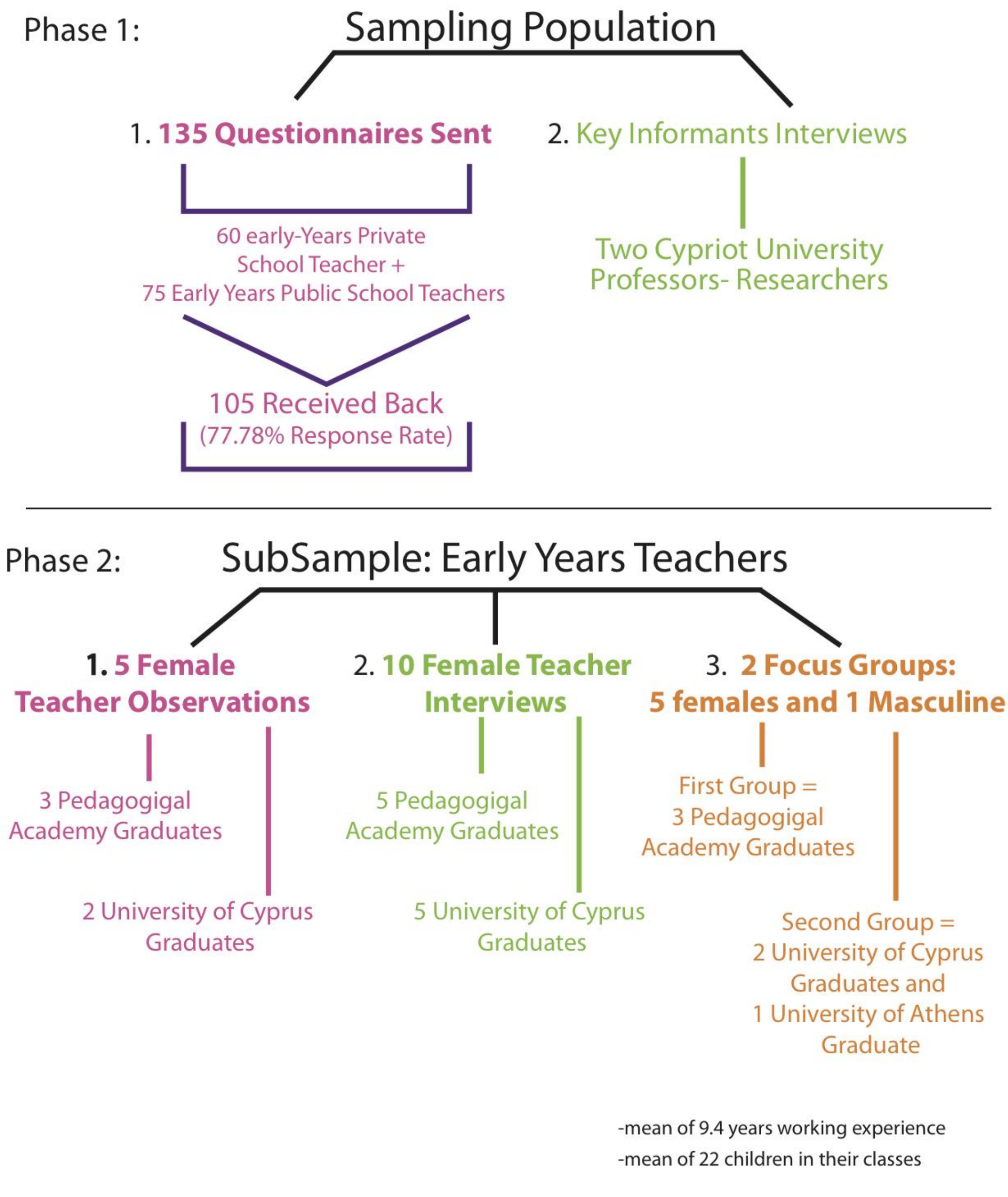
Specifically, from the one hundred fifty teachers that the questionnaire has been sent to, five white female early years teachers are selected to be observed, three of them have graduated from the Pedagogical Academy and two of them from the University of Cyprus. Ten early years teachers have been selected to be interviewed, five of them have graduated from the Pedagogical Academy and five from the University of Cyprus and six more early years teachers have been selected to participate in the focus groups, five of them are white females and one of them is a white male. Three of the focus groups participants have graduated from the Pedagogical Academy and two from the University of Cyprus and one from the University of Athens. All participants are working at governmental early-years' schools at the time, with a mean of 9.4 years of working experience and with a mean of 22 children in their classes.

6. 3. Choice of Instruments

The first phase of data collection includes quantitative data collected through the use of questionnaire and qualitative data collected through the key informants' interviews. Both these techniques are used in order to provide a general view and collect information in regard to population's characteristics.

The second phase engages research methods selected from the qualitative field. Specifically, observations, interviews, focus groups and document analysis are selected. These methods help to answer the research questions as qualitative research methods involve the meanings, concepts, definitions, characteristics, metaphors, symbols and description of things (Bieger & Gerlach, 1996). The data collected using the above instruments are then analysed for different purposes aiming at understanding the participants' experiences, ideas, thoughts and views.

Tables & Figures 9: The subsample selection for this study



6. 3. 1. First Phase of Data Collection: The Use of Questionnaires

Questionnaires are a popular way of collecting information for quantitative studies, and according to Peterson (2000) a questionnaire is a carefully formulated sequence of questions, structured to obtain information that meets the requirements of a research project. The main reason for choosing to gather data using questionnaires is clearly summarised by Cohen, Manion and Morrison (2007, p.317) who said: *"The questionnaire is a widely used and useful instrument for collecting survey information; providing structured, often numerical data, being able to be administered without the presence of the researcher, and often being comparatively straight forward to analyse".*

The use of the questionnaire has been helpful as it is a cheap and quick method for gathering certain types of information (Bell, 1999). This enables the collection of a large amount of data which are relevant with this study in a cheap way and makes convenient use of time with minimal effort (Wilkinson & Birmingham, 2003). An additional value of using the questionnaire is that it helps protect the respondent's anonymity (Munn & Drever, 1990). According to Robson (2002), questionnaires allow anonymity which can encourage honesty when sensitive areas are involved. Every participant may feel comfortable and more willing to answer each question. Consequently, it is hoped that with this approach, teachers were encouraged to give reliable responses. A questionnaire is a constructive tool used widely in research because of all these important benefits (Munn & Drever, 1990).

On the other hand, Munn & Drever (1990) also recognised some limitations in terms of using questionnaires which have to do firstly with the information collected, as it tends to describe rather than explain why things are the way they are. Secondly, the information can be superficial, and thirdly, the time needed to draft and pilot the questionnaire is often underestimated, so the usefulness of the questionnaire is reduced if preparation has been inadequate (Munn & Drever, 1990). Moreover, questionnaires can be dangerous if the percentage of questionnaires returned is small[5].

Robson (2002, p.233) also draws attention to the fact that "respondents may not treat the exercise seriously, and you may not be able to detect this". As a result, there is a possibility that the participants do not provide true information. Furthermore, Crabtree & Miller (1999, p.89) argues that: "the worst case scenario is if the respondent simply guesses at the meaning of the question and answers it incorrectly". The effect of this would be to collect inaccurate information. Moreover, despite questionnaires offering a huge amount of information, they cannot go into depth investigation. Furthermore, the questions used in a questionnaire can be biased, thus they need to be tested through a pilot study before sending it out for completion.

However, all the above have been limited as much as possible by using other methods of collecting data, as well. In addition, the questions have been checked carefully to ensure that they are free of bias and that they do not lead the respondents towards a particular answer (Brown & Dowling, 1998). Undoubtedly, this factor can contribute to valid results. Moreover, designing a short and easy to understand questionnaire has helped to encourage a high rate of returned questionnaires, which is nearly seventy eight per cent (77.78 %). What remains is

[5] This does don apply to this case study since the response rate was 77. 78%.

the respondents to answer precisely, so that necessary information can be collected.

6. 3. 1. a. Designing the Questionnaire

Muijs (2004) highlighted that the way that a questionnaire is designed and the questions are worded affects the answers that the respondents will give. Therefore, while designing the questionnaire, it is important to think carefully about the kind of questions to ask. As noted by Peterson (2000, p.13), *"Questionnaire construction is one of the most delicate and critical research activities. Asking the right questions – questions that provide valid and reliable information for making a decision or investigating a topic – is probably as much of an art as any aspect of research".* To achieve this, the questionnaire has gone through several drafts, which were discussed with the supervisors, in order to construct reliable and valid questions regarding the topic and the research questions. It was also necessary to make sure that the language used is unambiguous by using simple, understandable language, as well as by piloting the final version of the questionnaire.

Specifically, the questionnaire consists of different types of questions, such as closed questions (questions 1, 2, 3, 4, 5 ,6 and 7), open-ended questions (question 11), rating-scale questions (questions 8 and 9) and one ranking question (questions 10) (see appendix 1). This approach offers the opportunity to cover many subjects and issues with the use of different types of questions and approaches so that collecting the information required is allowed. Additionally, the use of dissimilar types of questions has proved to be more productive and constructive for the study and for the participants as it has helped to avoid boredom.

The questions of the questionnaire rotate around five main topics that stimulate a lot of interest. These refer to: a) the participants' background (Part A: who are the participants in this study), b) their confidence in regard to teaching Natural Sciences (Part B: 1.1, 1.2, 1.6, 2.1), c) their satisfaction in regard to their subject knowledge (Part B: 1.3, 1.4, 1.5, 1.8, 2.2), d) their preferences in regard to teaching Natural Sciences topics (Part B: 3.1, 3.2) and, finally, e) the school environment, equipment and time (Part B: 1.7).

Most questions used in the questionnaire are fixed-response items, which entail the use of a rating scale. This is a very useful device for the study as it builds in a degree of sensitivity and differentiation of responses while still generating numbers (Cohen, Manion & Morrison, 2007). The Likert scale, which provides a range of responses to a given question or statement (e.g. 1= strongly disagree, 2= disagree, 3= neither agree nor disagree 4=agree, 5= strongly agree) is mostly used. Having a mid-point response can sometimes prove to be dangerous. However, from my point of view, it is necessary to include it in the Likert scale as it would be unethical not to offer this option to participants.

Closed questions are avoided wherever possible because, even though they are easier to answer and analyse, they would give little information as the answer is pre-specified (Crabtree & Miller, 1999). Such questions are necessary, though, to collect information like: 1) gender, 2) lessons during high school, 3) years of experience, 4) class they teach this year, 5) number of children in class, 6) type of school and 7) country of studies.

Rating-scale questions and ranking questions are mostly used as they offer a number of possible responses and the respondents have the flexibility to answer them according to their opinion (Crabtree & Miller, 1999). Open-ended questions can also be useful, as they are free of any constraints, and they allow the respondents to give specific and precise answers. Thus, one open-ended question, which aims at allowing the participants to freely add whatever they consider to be useful for the research, is used at the end of the questionnaire.

When the questionnaire design was completed, the questionnaire was piloted, corrected and, finally, sent to one hundred and thirty five (135) public and private pre-primary schools in Southern Cyprus. It was completed and returned by one hundred and five (105) teachers. The systematic method for sample selections has been used in order to choose the schools where to send the questionnaires. The pattern used for selection is one every consecutive 10^{th}, which means that one in every ten schools is selected from an official catalogue retrieved from the Ministry of Education, which includes all primary and early years/kindergarten schools of Southern Cyprus.

6. 3. 1. b. Piloting the Questionnaire

A pilot study is always necessary before sending a questionnaire out to the selected schools. The pilot study aims at identifying how long it takes the teachers to complete the questionnaire and, also, at checking the appropriateness of the questions. After designing the questionnaire, we needed to ensure that the questions used are easy to understand and fill in (like for example, if the Likert-scale statements are clear enough). To do that, the questionnaire was sent through electronic mail to fifteen teachers who had finished their first degree studies but at the moment were not working as they were studying for their Master or Doctorate degrees. However, all of them had some kind of teaching experience.

The pilot study revealed that some changes had to be made as they would make the questionnaire easier to complete and the questions more understandable. Specifically, Part A included a question which asked teachers to identify the place where they graduated from. This question was initially the fourth one but the teachers' comments during the pilot indicated that it needed to change place and go to the end of Part A because it was confusing for the participants. In addition, the initial questionnaire had a question which contained two sub-questions which referred to the class that each teacher teaches this year and the number of children in the class. The pilot study showed that this question needed to be divided into two questions, fourth and fifth question, and the fifth question had to be made clearer and, also, include all primary classes and the option for mixed classes. This helped me to identify those questionnaires that were completed by teachers who do not teach early years children and, thus, should not be included in the data analysis.

Similarly, question number six, which refers to the type of school, needed to be made clearer, as well. Extra explanation needed to be given so that the teachers would know that they had to tick only one box that would represent either city or village, as some participants during the pilot study ticked two different boxes. Furthermore, Part B included a question which asked the participants to put the four given statements in hierarchical order (the last question in the questionnaire). The pilot study revealed that this was quite confusing for the participants, thus, the instruction needed to be more comprehensible. Thus, the final instruction asked the teachers to rank the statements starting from number one as the factor that affects their teaching the most and five as the factor that affects it the least. Finally, question Number nine, Part B, was not initially divided into four parts but the pilot study presented the need to split the section into parts a, b, c and d.

The above changes were made in an attempt to improve the questionnaire's appearance, to make the questions more understandable and easier to complete. This questionnaire was, then, completed by ten different participants in a second pilot study. This second pilot study helped to ensure that the questionnaire developed did not include any confusing questions and did not take more than twenty minutes to complete. As a result, this questionnaire was considered to be applicable for use.

6. 3. 2. First Phase of Data Collection: Key Informants' Interviews

The interview technique was also used to gather important information about the teachers' background studies. More details regard to the use of interviews will be given later, while explaining the second phase of data collection. Here, the aim is to explain how the technique was used to interview individuals who are considered to have important information to offer in regard to student teacher's studies.

Two professors who teach at Universities in Cyprus were selected to be interviewed as they were identified to be experts in regard to children's preconceptions. Both of them have done relevant researches in the past and are currently teaching Natural Sciences to student teachers. A semi-structured interview was designed to facilitate the interview. It included questions regarding student teachers' training, with specific reference to children's preconceptions. The questions made covered three main areas of interest which were: 1) A definition for children's preconceptions and teachers response to them from the key informants' point of view, 2) the Universities' role during the teachers' studies and afterwards, and 3) the kinds of resources that are available to teachers (see appendix 2).

As a result, after explaining the aim of the study and giving some basic information to the interviewees, a discussion began in regard to children's preconceptions. Firstly, the key informants were asked to give their personal opinion and definition about children's preconceptions and their opinion on the teachers' understanding of children's preconceptions. They were asked to explain how teachers usually deal with children's preconceptions based on their personal experience.

The second part of the discussion included questions regarding how the different universities/institutions enable future teachers to cope with children's preconceptions and how the key informants themselves do this. Important information about what student teachers are taught in relation to children's preconceptions was collected at this point along with information about teachers' professional development opportunities. This information relates to teachers' subject knowledge.

At the last part of the discussion, the aim was to collect information regarding the different kinds of resources which are available to teachers. Specific reference was made to the use of the Reference Book, as it is one of the main resources that teachers use to teach Natural Sciences. At this point, the key informants were also asked to talk about their personal work in regard to children's preconceptions and if they had something that they would like to add that would be useful for this study.

The key informants' interviews lasted approximately one hour and provided useful qualitative data. The information collected, in addition to the data collected through the questionnaires, helped to design the observation, the interviews and the focus groups in order to facilitate further investigation. This emerged the beginning of the second phase of data collection, which is described below.

6. 3. 3. Second Phase of Data Collection: Observations

In an early years classroom a lot of events can take place; for example teachers and children make questions, new concepts are explained, children experiment and talk to each other. For a study like this one, it is important to have an insight into what is going on in a traditional early-year classroom in Cyprus. Thus, the lessons observed related to 'Water Cycle' because of the need to identify how teachers articulate children's preconceptions.

Classroom observation can give information on what actually goes on during teaching and learning (Wragg, 1994). In this case, by observing teachers' direct actions, data and knowledge can be gained about how teachers teach the specific topic, how they identify children's preconceptions and how they use them during the lesson. Observations can give direct access to the event or interactions that are the focus of this study (Simpson & Tuson, 2003, p. 16). As a result, the data collected from observations greatly enriched and engaged the database of the study.

According to Simpson and Tuson (2003), a disadvantage is that observations demand effort, time and resources and they are susceptible to the observer's bias. Another issue that this study acknowledges is the fact that when a new person (like me, the researcher) comes to a classroom to observe, then the very presence of an additional adult who is not normally present may itself influence what normally happens. It is not easy to identify what might change because this depends on many factors (like for example how common it is to have visitors in the class, the age, the gender even the dress of the observer). Finally, the observer needs to remember that she cannot see everything and that choosing to look at one direction may miss other things that happen (Marriott, 2001).

However, these weaknesses were considered while planning the study and the necessary actions were made in order to minimise the disadvantages as much as possible. One of the actions taken was the planning of an observation schedule in order to facilitate the note-taking. More details in regard to designing and piloting the observation schedule are given below.

6. 3. 3. a. Designing and Piloting the Observation Schedule

A focused observation concentrates on a specific aspect of teaching or learning. This can relate to the class as a whole, to groups or individuals. The focus of this study is on the teachers, thus, the observations focus on the early years teachers of each classroom. Early-years teachers engage as many as a thousand interpersonal exchanges in a single day and there is a change in activity every five to eighteen seconds during an average lesson (Wragg, 1994). A focused observation can provide a great deal of information about the quality of teaching but can lose sight of the overall context of the lesson (Marriot, 2001). This indicates how difficult it can be for an observer to capture and note all this information.

To facilitate this, an observation schedule was designed using the systematic approach which gives further options: category system, which refers to recording all instances that take place in ten minutes and noting the frequency, or sign system, which refers to tally only once in each of five two-minute segments (Wragg, 1994). Both of the systems show all interactions but the sign system allows the observer to preserve something of the flavour of each lesson segment.

As a result, the schedule was designed in a way to help the observer take notes of what was happening every five minutes. An average lesson lasts up to thirty-five minutes. However, the observation schedule consists of nine columns, each one representing a five-minute period of the lesson, to cover those lessons that might last more than thirty-five minutes, as well. An additional column, which is the first column of the table, indicates a possible action that usually takes place in an early years Natural Sciences lesson. So, the observer could tick the appropriate action that took place in every five-minute period. The main focus, though, would be on the actions that are relevant to preconceptions. Finally, the last column provides space to add any general comments about the lesson that could be important in understanding or analysing the observation. The observation schedule is available at the appendix (see appendix 3).

The first column, which includes possible actions of an early years' science teacher, was developed based on the literature review, on the research questions and, also, on the specific questions that Marriot (2001) developed in her book to assist teachers' observation. Some of those which affected the design of the observation schedule at some degree are presented below:

- Expectations:
    - Does the teacher have a good knowledge of the level at which pupils are already working?
    - Is the level of challenge high enough for all children?
    - Is there an emphasis on children working hard and accurately and presenting their work well?
- Planning:
    - Are teaching strategies identified in the planning?
    - Does the planning meet the needs of the range in the class?
    - Are the lesson objectives clear?
    - Are links with previous work clear?
- Teaching Methods:
    - Is there an introduction brisk? Does it share aims and objectives for the lesson with children?
    - Are instructions given clearly and precisely?
    - Are methods appropriate to the work?
    - Is the teaching style right for the content (for example: oral, practical, problem-solving, discussion, explanation, exposition, demonstration?)

    - Does the teaching style help to motivate children?
    - Does the teacher make proper use of voice, humour, challenging questions, feedback?
    - Is the teacher able to deal with the unexpected?
    - How good is the match between planning and delivery?
    - Is there a summary that reminds children of what they should have learned and that gives a brief indication of what it is leading on to?
- Teaching:
    - What questions does the teacher ask?
    - Are general questions followed by direct questions?
    - Are children confident enough to risk making a mistake?
    - How does the teacher use children's mistakes and preconceptions to move the work on?
    - What questions do children ask?
    - Do children seem interested in and engaged to the topic?
    - Are they listening to the teacher and to each other?
    - If the teacher is demonstrating or using something, can all children see what is happening?
    - Does the teacher share the objective with the children?
- Pace and Timing:
    - Is there a smooth transition between activities?
    - Are the instructions given clearly so that everybody knows what to do and how long they have?
    - Are the children working independently or in small groups?

    - Is there enough time for at least a brief review of what has been achieved?
- Learning Environment:
    - The condition of the room: how well is it arranged?
    - Does the room reflect the subject being taught?
    - Are the displays helpful for the provision of a rich environment?

All these questions helped to define the actions included in the first column of the observation schedule. They also helped the observer to manage her focusing during the observation.

The observation schedule was then piloted in a private school's classroom and the lesson and teacher observed did not take part in the actual research. An early years' teacher was observed while teaching the topic of 'Sinking and Floating' to five-year-olds. The pilot study helped to check the appropriateness of the observation schedule that was designed and, also, practise taking notes. Besides that, the pilot study also helped to identify the best position to place the voice recorder. Different places were tried during the observation until the best one was identified which was between the teacher and the children but closer to the teacher.

The pilot study helped in making some minor changes in order to make it easier to complete the schedule and take notes easier and more efficiently. For example, the page setup of the schedule was changed from landscape to portrait in order to have more space for extra comments and notes for each period of time; before the pilot study, there was only a small space for extra comments at the end of the schedule.

Additionally, the pilot study indicated that there was a need for more distinction about the different actions carried out by the teacher. For example, one action was ‘Demonstrating-Experiment’, which, after the pilot, was separated in two parts: ‘A: Herself’ and ‘B: Pupils’. This helped to save time and, also, make the description of the action more specific. The same happened with the action of ‘Summarizing/Reviewing’. On the other hand, ‘Telling something – Giving Information’ was changed to ‘Telling something (Story)’, which is considered to be a minor change, and it was made just because teachers use stories quite often when teaching early years children. The last change that was made was to add the action of ‘Making a table/graph’, which is often used with older children, but it could be helpful to include it to be on the safe side.

The second observation schedule was also practised and piloted to confirm that the changes made helped to actually improve the schedule. It also helped to check the appropriateness of the new actions and the changes made. Additionally, making another observation and practising the observation schedule, even if only some minor changes were made, helped me to practise and, thus, feel more confident and prepared during the actual observations.

6. 3. 3. b. Conducting the Observations

The observations came after the completion of the questionnaires' collection, which signalled the beginning of the second phase of data collection. As this is an explanatory design, the first phase guided to the second phase. The questionnaires were randomly sent to teachers in schools all over South Cyprus and, then, five teachers were selected to be observed (more details about this selection is given in the 'sample and participants' section).

During the observation, the schedule guided the observer and was used in conjunction with note-taking. This helped me to observe and note as much information as possible. Note-taking allowed making immediate and fresh notes about what was happening within a short period time. Additionally, the teacher was asked in advance to provide the observer with the lesson plan, which would make the lesson objectives and the activities that the teacher was planning to follow clear. After the end of the lesson, the lesson plan, in addition to the notes taken, could help to create a mental representation of the lesson flow and content and the exact series of events at any time.

A voice recorder was also used as a second way of recording the observation. The voice recorder was placed between the teachers and the children but a bit closer to the teachers, as the main focus was on the teachers and the aim was everything they said. This was very helpful because it could be replayed several times afterwards and allowed the lesson to be transcribed. It also helped to identify if there was anything that the observer had not spotted because of the distance between her and the teacher.

The complete transcripts were then imported into NVivo, which enabled really detailed analysis and permitted analysis by several people. It is worth noting that there was a high cost of time to have each lesson transcribed but, fortunately, the small number of the lessons helped with this. It was worth doing it, though, because text can be distributed easily and several people can be working on the same transcription at the same time and not necessarily at the same place.

To be more precise, as it has already been said, the lessons observed were given using the Greek-Cypriot dialect. At a first stage, the observer wrote down everything said by the teacher and the children, in the exact way that it was said. After that, copies of the first transcription of each lesson were sent to friends and colleagues, who were asked to translate them in English. Then, the transcriptions generated for each lesson were compared in order to develop the one that would be the most representative and final, of course. After that, I compared this final one to what had been noted in the observation schedule and the voice recorder to make sure that everything was as identical as possible to the original lesson.

In addition to the information given through the lesson plan, the whole lesson was recorded in detail with the use of both an observation schedule and a voice recorder. The use of a video camera was also considered during the research design. However, the final decision was not to use it because usually teachers do not feel comfortable when being video recorded. They tend to behave differently and some of them might even refuse to be observed at all. Instead of that, notes were taken in regard to visual clues that would help to understand and analyse the lesson in more depth.

As a result, a great deal of attention was also given to non-verbal aspects of the teachers' actions like posture, movement, gestures, facial expressions and eye-contact, which can be called 'body language'. Such an example is that some early years' teachers might crouch alongside small children to minimise the height difference, but when they are angry they might draw themselves up to their full height, maximising height difference to establish or maintain dominance.

In order to avoid having a classroom behaving differently because of the observer's presence, like described above, I as the observer arranged to visit the classrooms that were going to be observed in advance. The visits helped the teacher and the children to feel less threatened on the day of the observation as they were already familiar with the observer. To accomplish this, the observer visited at least twice each classroom and made sure that everybody had a clear idea of the aim of the study, the style of the observation and the follow-up there would be. During each visit, the observer tried to smile and be friendly in order to create a relaxed atmosphere, recognising that the teacher and children might be nervous.

On the first day of the visit, the observer asked them to complete an information sheet which required them to answer some questions, such as the years of experience and the number of children in the class (see appendix 4). The teachers were also politely asked if they could provide the lesson plan of the lesson that was going to be observed, so that the observer could have instant access to planning. These helped the observer to know the class (for example, mixed ability), the content, teachers' expectations and the nature of the lesson (introductory, middle or end of a series lesson). All teachers observed were asked to provide a lesson plan which was used to answer the following questions:

- Can the learning objectives be identified clearly?
- Is there a match between the planning and the reality of the lesson?
- Is there enough work for the whole class?

- How is the teacher making sure that the children will make progress?
- How is the teacher planning to use children's prior knowledge and preconceptions?

All the questions, in addition to the ones stated above, will also help during the analysis of the observation.

Finally, it was made sure about when and where the observation would take place and that a chair would be available for the observer to sit (sounds obvious but it is surprising how often an observer is stranded in the doorway looking for somewhere to sit down; this has the effect of drawing attention). The observer was as open-minded as possible and was prepared to accept that different approaches can work. Overall judgements were not made early, as this could manipulate the understanding of what would happen later. Thus, the good planning, in addition to piloting and using the observation schedule, the note-taking and the voice recorder helped to minimise the disadvantages that observations might have, which were described before.

6. 3. 4. Second Phase of Data Collection: Interviews

Interviewing was used at this phase as it is one of the major tools of social and educational research (Hitchcock & Hughes, 1989). Knowledge is generated between humans often through conversation, and interviews are conversations between people aiming to understand one another. An interview is a two-person conversation initiated by the interviewer for the specific purpose of obtaining information. The use of the interview in this study marks a move away from just seeing teachers as subjects that can be manipulated and data as something external to individuals (Cohen, Manion & Morrison, 2000).

The interviews were used in order to listen to people's external realities and internal experiences. As Silverman (2000) described, interviews are the researcher's chance to see the world from the perspective of the respondent's eyes. The interviews gave the opportunity to this study to see the situation under investigation from the perspective of the respondent-teachers' eye. A direct question to teachers about what is going on is an obvious shortcut and was very helpful to the seeking of answers to specific research questions. Moreover, an interview is literally an inter-view, an inter-change of views between two persons conversing about a principle of natural interest (Chirban, 1996; Kvale, 2007).

Interviewing as a research method involves the researchers asking questions and hopefully receiving answers from the people being interviewed (Robson, 2002). An interview could be structured, semi-structured or unstructured. The example of a highly structured interview is the interview survey, which is like a questionnaire with fixed questions in a pre-directed order and standardised wording, where most responses to most questions have to be selected from a small list of alternatives (Robson, 2002). The more standardised the interview is, the easier it is to aggregate and quantify the results. But, as noted by Johnson & Christensen (2008, p.205), structured interviews offer *"less flexibility in relating the interview to particular individuals and circumstances; standardised wording of questions may constrain and limit naturalness and relevance of questions and answers".*

Unstructured interviews can be very informal as the interviewer has a general area of interest and concern but lets the conversation develop freely within this area. This kind of centred-on-a-topic interviews may produce valuable data, but a researcher needs experience to accomplish that, as it requires a great deal of expertise to control it and a great deal of time to analyse the data (Bell, 1999). As Hitchcock and Hughes (1989) discussed, the success of the unstructured interview, depends heavily on the relationship that develops between the interviewer and the respondent. They added that it is crucial for the interviewer to develop a familiarity with the biographical and contextual features of the respondent's life history, outlook, customs and life-style in order to be able to relate more fully and in more appreciative way with those being interviewed.

However, semi-structured interviews, which were used for this case study, offered flexibility and freedom and, in some cases, I was able to change the question wording, or give extra explanations when needed. Similarly, some questions that seemed inappropriate for a specific teacher were omitted, or others added, as the semi-structured design provided this possibility (see appendix 5). The use of pre-determined questions, but in a modifiable way, gave the opportunity to act accordingly to what was more appropriate each time (Robson, 2002).

Moreover, the order of the interview could be controlled, gave space for spontaneity and I could press not only for complete answers but also for responses about complex and deep issues. In short, as identified by Cohen, Manion & Morrison (2007) unstructured interviews are a powerful implement for researches. Their adaptability is empowered by the fact that the researcher can follow up ideas, probe responses and as mentioned above, investigate motives and feelings (Bell, 1999).

A major advantage of using interviews was their adaptability as interviews can be a flexible and adaptable way of finding things out (Chirban, 1996). A skilful researcher-interviewer can follow up ideas, probe responses and investigate motives and feelings, which a questionnaire can never do (Bell, 1999). The human use of language was fascinating during the interviews, both as behaviour in its own right, and for the virtually unique window that it opens to what lies behind teachers' actions. Observing behaviour is clearly a useful enquiry technique, but asking people directly about what is going on was an obvious shortcut for seeking answers to the research questions. Therefore, interviews helped to penetrate in depth into teachers' views in terms of how they believe that they respond to children's preconceptions.

The use of face-to-face interviews offered the possibility of following up interesting responses, modifying one's line of enquiry and investigating motives in a way that the questionnaires could not do. Bell (1999), argued that a response in an interview can be developed and clarified, as the way in which the response is made (the tone of voice, facial expression, hesitation, etc.) can provide information that a written response would conceal. Such non-verbal clues gave messages which helped me to understand the verbal response, possibly changing or even, in extreme cases, reversing its meaning. In particular, the interviews proved to be a flexible tool for data collection, as it enabled multi-sensory channels to be used: verbal, non-verbal, spoken and heard.

When using interviews, there can be problems, of course, like the possible lack of standardisation that can inevitably raise concerns about reliability and biases which can be difficult to rule out (Robson, 2002). Bell (1999) agrees that interviewing can be a highly subjective technique and, therefore, there is the danger of bias. However, these were minimised as the interviews were used in combination with other methods and were carefully designed and piloted. In addition, I tried to avoid any comments that would lead the responses in any way and I was as careful as possible to remain objective and avoid communicating personal views. Furthermore, I tried to communicate personal interest and attention to interviewees by being attentive, nodding the head and using appropriate facial expressions to communicate without leading the responses (Bogdan & Biklen, 2007).

According to what Foddy said (1993, p.185), an interview should also "avoid the use of "blab" words (i.e. words that are so abstract or general that they lack specific empirical referents)". Based on that, the questions were prepared in advance and they were also piloted in order to avoid using words that would not be understood by the teachers. In addition to this, an easy opening question was used to help the interviewees relax and encourage them to talk. Besides, questions were kept short, easy to understand and avoided academic language since length and complexity could be difficult to understand. The questions aimed at promoting a positive interaction, keeping the flow of the conversation going and motivating the teachers to talk about their experiences (Kvale, 2007).

Besides that, interviews can be time-consuming as anything under half an hour may be unlikely to be valuable and anything going more than one hour may be demanding unreasonable things from busy interviewees (Bell, 1999; Robson, 2002). Long interviews may also affect negatively by refusing the number of persons willing to participate, which may in turn lead to biases in the achieved sample (Robson, 2002). My opinion is that it is very important to have the professional responsibility to terminate the interview on schedule and that is why all interviews require very careful preparation. The actual interview sessions obviously varied in length but they all lasted approximately from thirty to forty minutes.

6. 3. 4. a. Piloting the Interviews

In the case of the semi-structured interviews, the pilot can help each researcher to check the order of the prepared questions in order to decide the one that will help the conversation to develop best and produce the maximum data possible in an interesting for the participant way (Bell, 1999). Practising the interviews helps to manage the interview structure and to make sure that the form of each question is clear, does not antagonise the respondent and allows the researcher to record interviewees in a way that will help to develop the interview in a meaningful and valuable way (Bell, 1999).

The prepared questions for the interview of the specific case study described above were tested in a pilot study, with two early-years teachers who did not participate in the actual research. The whole experience revealed that the questions were clear enough for the interviewee to understand and respond. The results of the pilot study also showed that the questions had a good and rational order that helped the conversation to develop, even if at some points some questions had to be added, in order to extract more details or make the interviewees talk more about a specific issue. The questions were asked in a different order each time as the order of the questions was affected by the answers given by the interviewee. The difficult task was to make sure that each time all questions were asked and enough time was given for the interviewee to respond to them. The pilot study helped me a lot in practising and improving this specific skill.

In addition, it is always possible to ask the interviewees in the pilot study to comment on the performance as well as on the interview schedule (Robson, 2002). At some points the interviewees asked for more information in regard to a question or more specific explanations in order to answer a question. These were considered while conducting the actual interviews, even if there is a big possibility that the specific interviewees needed more clarification as they were in-service teachers who had been away for a number of years to complete their doctoral studies. As a result, their experience in teaching Natural Sciences was limited. For example, one of the interviewees actually said: “I do not know much about the specific subject because my experience on teaching Natural Sciences is quite poor and that is the main reason that I am asking for more information before answering a question. I want to make sure that I am talking about the correct thing.”

In general, the pilot study did not show that any significant changes should be made in regard to the interview structure and it also helped to identify how long the interviews would be. This helped to organise the interview appointments and also to inform the interviewees about how long the interviews would be, since it was important for the participants to be able to arrange their schedules. The interviews would not last more than forty-five minutes.

6. 3. 4. b. Conducting the Interviews

In order to gather rich and valuable data filled with words and also non-verbal clues, the interviews were recorded with the addition of note-taking. These notes gave messages which helped to understand the verbal response, as they included things that a recorder could not capture, like body language or facial expressions (Bogdan & Biklen, 2007). During the interviews, I was able to listen to what teachers said, hear them express their opinion about teaching Natural Sciences and children's preconceptions and learn about their views on their own work.

The main purpose of the interview was to find out how, why and when teachers identify (or do not identify) children's preconceptions and what kinds of methods they used to do that. The interview also included questions which aimed to identify what general knowledge teachers have in regard to children's preconceptions (for example, by asking them to give their own definition for this) and about how teachers usually teach a specific Natural Sciences topic (like the water cycle).

Additionally, Robson (2002) continued that tapes must be transcribed and then analysed as soon as possible. All these cost time as well, thus, time-planning and time-budgeting is a crucial skill for using interviews successfully. That is why the interviews for this research were prepared properly, arrangements were made to visit and the necessary permissions were secured in advance. What is more, the arrangements were confirmed and appointments were rescheduled when necessary to cover absences. As a result, the interviews produced rich data filled with words that revealed the teachers' perspectives, and transcripts were full of details and examples.

6. 3. 3. Second Phase of Data Collection: Focus Groups

Focus groups, or group interviews, are also among the most widely used research tools in the educational research. They can be, and have been, used as the primary data collection method in previous studies, like for example the research Osborne and Cosgrove conducted in 1983 and Valanides, Gritsi, Kampeza & Ravanis's research which was conducted in 2000 (both studies are described in the literature review). However, they are commonly used in conjunction with other methods like observations and individual interviews (Robson, 2002). In this case study, they were used in conjunction with individual interviews, observations and questionnaires.

The generic term of 'group interviews' has tended to be used interchangeably with 'focus groups', because of the latter's popularity, even though it has specific characteristics that will be discussed later on (Robson, 2002). Focus groups involve a number of individuals who discuss a particular subject under the direction of a moderator who promotes interaction and assures that the discussion remains on the topic of interest. The moderator is the key to assuring that the discussion goes smoothly (Stewart, Shamdasani & Rook, 2006).

Interviewing groups of people is used more frequently in recent years. Focus groups are a useful way of conducting interviews. Hitchcock and Hughes

(1989) noted that researchers interested in consensus formation, interactional processes and group dynamics may find that focus groups are useful because they allow one way into understanding how people interact in considering a topic and how they react to disagreement. For qualitative researches, focus groups are group interviews that are structured to promote talk among the participants about particular issues. In the specific study, focus groups were used to bring teachers together and encourage them to talk about the subjects of interest (Morgan, 1997).

Focus groups can have either a standardised or a non-standardised form (Hitchcock & Hughes, 1989). Focus groups can be highly structured, semi-structured or unstructured which is very similar to one-to-one interviews. For the specific study, semi-structured focus groups were chosen, as they would be easier to be used by a new researcher like myself. Most common versions have a substantial degree of flexibility and are effectively some form of mixture with characteristics of a discussion as well as of an interview. Even though general topics or specific questions are presented by the researcher, the traditional interview format of alternate question and answer is both difficult to maintain and eliminates the group interaction, which was a particular strength of the group interview (Robson, 2002).

Focus groups are an open-ended group discussion guided by the researcher, they typically extend over at least one hour and usually require from eight to twelve participants, although smaller groups have been used in past researches (Robson, 2002). Cohen, Manion and Morrison (2007) also discussed the issue of group size and they led to the conclusion that a group of few people can put pressure on individuals while a large number of participants leads to group fragment and loses focus. They suggest that a group of six or seven is an optimum size. Stewart, Shamdasani & Rook (2006) also discussed the ideal number of participants for a focus group and they suggested that it should involve eight to twelve individuals.

With the use of focus groups the study gave the potential to teachers to discuss and produce a wide range of responses (Cohen, Manion & Morrison, 2007). Focus groups share with questionnaires the advantage of being an efficient way of generating substantial amounts of data, and, apparently, being easy to carry out. Focus groups as a method is a highly efficient technique for qualitative data collection since the amount and range of data are increased by collecting from several people at the same time (Robson, 2002). The same continued that with focus groups, the researcher can naturally control quality and also group dynamics help to focus on the most important topics and it is fairly easy to assess the extent to which there is a consistent and shared view.

It is important to recognise that the amount of direction provided by the interviewer does influence the types and the quality of the data obtained from the group (Stewart, Shamdasani & Rook, 2006). The interviewer was very careful in regard to that and tried to help group participants to stimulate each other to articulate their views or even to realise what their own views are (Bogdan & Biklen, 2007).

It was also very important that the participants enjoyed the experience and that the specific method was relatively inexpensive, flexible and had been set up quickly. Focus groups are also economical on time, even if they produce less data than interviews with the same number of individuals on a one-to-one basis. In addition, with focus groups, participants were empowered and able to make comments in their own words, while being stimulated by thought and comments of others in the group. Finally, the focus groups managed to encourage people who were unwilling to be interviewed on their own, because they probably felt that they had nothing to say, to participate.

On the other hand, it can be difficult to follow up the views of individuals and, also, group dynamics or power hierarchies affect who speaks and what they say. Robson (2002) noticed that a particular problem is when one or two persons dominate or when conflicts arise between personalities. That is when power struggles may detract from the interview and there may be conflicts of status within the procedure. Bogdan & Biklen (2007) also noticed the fact that individual members that talk too much might be a problem during the interview of a group along with the difficulty of keeping the conversation within topic. Furthermore, confidentiality can be a problem between participants when interacting in a group situation and, therefore, the results cannot be generalised as they cannot be regarded as representative of the wider population (Robson, 2002).

The number of questions asked during focus groups is limited (typically fewer than ten major questions can be asked in an hour). While facilitating, the group process requires considerable experience and might be difficult for new researchers. Another major difficulty with focus groups can be that individuals may not share essential experiences they have had because they are too embarrassed to share them with a group. Bogdan & Biklen (2007) noticed that with focus groups, although the researcher may gain in stimulating talk among participants, she may lose the quality of data, so a decision on what is needed to be acquired from the interview must be made. Moreover, the live and immediate nature of the interaction may lead an interviewer to place greater faith in the findings than is actually warranted.

Another disadvantage can be the problem of coding the responses of group interviews and, also, the fact that they are of little use in allowing more personal matters to emerge, as it is difficult for the interviewer to use follow-up questions with one specific member of the group. In other words, we could say that focus groups have a contrived nature, which is both their strength and their weakness as they are unnatural settings, while yet they are focused on a particular issue. Therefore, they can yield insights that might not have been available otherwise; for example, through a straightforward interview (Cohen, Manion & Morrison, 2007). In order to avoid the above, the interview process was well-designed, piloted and managed and the focus groups were used in combination with other methods which helped to limit their disadvantages. If these had not happened, then the participants might not share their views and bias could be caused by the domination of the group by one or two people, a scenario which thankfully did not happen. The next section explains more about piloting the focus group structure and questions.

6. 3. 5. a. Piloting the Focus Groups

The focus group's questions and structure (see appendix 6) were piloted with three early-years' teachers that did not participate in the actual research. The aim was to check if the designed questions were clear enough and if the order that they were going to be asked was helpful and promoted the development of the conversation. There was a need to confirm that the structure and the order of the questions had quality that would produce a conversation with a natural flow that would provide rich and trustworthy data. Additionally, it was a chance to check if at least one of the places where one focus group was going to be conducted had been organised well enough, so that everyone could see and listen to each other. This is also supported by Denscombe (1998, p.175), who claimed that 'the researcher needs to try to get a location in which they will not be disturbed, which offers privacy, which has fairly good acoustics and which is reasonably quiet'.

The pilot of the focus group confirmed that the location is very important in order to reach success for the focus group. To ensure that, one of the focus groups took place in the living room of a house that was familiar to all the participants of the specific focus group. The pilot study also helped me to practise the technique and ensure that no one would disturb the focus group at any time and to ensure that a private and quiet environment would be available for the whole time. This pilot study also helped to test how long the focus group would last, so that the participants could be informed and organise their schedules in advance.

The pilot study also helped to ensure that the designed questions were clear and easily understood by the participants and also that the order was good enough. However, during the actual focus groups, the question order could change if necessary. Finally, the pilot study helped to identify some minor issues like the necessity of providing pens and papers to the participants in order to be able to take notes or write something if they wished to.

6. 3. 5. b. Conducting the Focus Groups

The focus groups designed for this case study involved six participants in total and lasted approximately one hour each. Specifically, two focus groups were carried out and involved six participants; two of these six participants that participated in the focus groups were also observed. It was also kept in mind that group interviews require skilful chairing and attention to the physical layout of the room. The room had been carefully chosen so that everyone could see everyone in order to facilitate the interaction between the participants.

As a result, one of the focus groups took place in the school's staff room on a chosen working day and time when all three teachers were available and were free of teaching obligations. This focus group was small in number as there were not a lot of teachers available at the same time. The second focus group took place at my house which was a familiar place to most teachers that were going to be interviewed. It was hoped that more teachers would participate in this focus group but in the end no more teachers were able to take part because of technical issues (distance and busy schedule).

The focus groups were given the topic of discussion, but there were several opportunities for interaction within the group rather than a backward and forward conversation between the interviewer and the group. This means that the data emerged from the interaction of the group. The participants interacted with each other rather than with the interviewer in a way that the views of the participants emerged (Cohen, Manion & Morrison, 2007).

6. 3. 6. Document Analysis

Documentary analysis was also used to assist understanding of how early-years' teachers might be affected by the reference book that is mainly used as a guide for Natural Sciences teaching. Documents like the one analysed here are literally all around and they are an integral part of teachers' lives and teaching.

The positive sight of using documentary analysis is that the document used was not affected by the fact that it was being used and the document analysis could be done anytime and without any problems. Additionally, the data can be subject to reanalysis, allowing reliability checks and replication studies. Nevertheless, it is a low cost form of collecting information, especially of documents like the specific one which is available and easily accessible.

On the other hand, during document analysis, we need to keep in mind that documents are written for specific reasons, which can introduce bias into the research. This, however, can be controlled in cases like the one described here, as document analysis is used in conjunction with other data sources (Robson, 2002).

Document analysis was a useful research technique as it provided replicable and valid inferences from data to their context (Robson, 2002). As McCulloch (2007) identified, to understand documents means to read between the lines of the material world. Getting between the lines is the core of the document analysis if we are to understand the deeper purpose of a document.

6. 3. 6. a. Conducting the Document Analysis

The main focus here was the use of document analysis as a secondary, or else, supplementary method in this multi-method case study. Document analysis is often used in conjunction with interviews and observations for triangulation purposes or to provide something of a longitudinal dimension to a study when a sequence of documents is available extending back in time (Merriam, 1998).

In this case study, the use of document analysis helped to examine how the reference book, entitled ‘Natural Science in the Kindergarten – A reference book for the Early-years Teacher’ (original title: Οι Φυσικές Επιστήμες στο Νηπιαγωγείο – Βοήθημα για τη νηπιαγωγό) can affect the teacher’s Natural Sciences teaching. This reference book was published in 2004 after a series of seminars which aimed to inform early-years’ teachers about the new focus of early-years’ science education. From that point onwards, early-years’ Natural Sciences teaching became ‘process’-focused rather than ‘content knowledge’-focused. The book was published by the Cyprus Ministry of Education and the group of authors included university professors and in-service teachers, as well (Nicolaou & Kiriakidou, 2004).

This reference book was not randomly selected to be examined and analysed. It was selected because it was considered necessary to examine the content of this book, in order to understand the ways in which this book and the guidelines that it includes might affect the way that teachers teach Natural Sciences, including the ones observed. This happened because the questionnaire analysis indicated that early-years’ teachers in Cyprus make extensive use of this document when it comes to Natural Sciences teaching. Additionally, the key informants’ interview analysis confirmed that this reference book is the main resource for early-years’ teachers in Cyprus. As a result, the effect of the use of this reference by early-years’ teachers could not be ignored and it was considered necessary to investigate the perspective of this book, especially in regard to children's preconceptions.

6. 4. Ethical Issues

For this study, research ethics have to do with how participants are treated and how the data collected is handled (Vanderstoep & Johnston, 2009). In 1992, the British Educational Research Association (BERA) adopted ethical guidelines for educational research. In 2004, there was a revision of the Association's Ethical Guidelines for educational research, which was built on the 1992 statement in two significant ways: first, it tried to recognise the academic tensions that a multi-disciplinary community generates when dealing with the complex research issues that characterise education context and, secondly, it included the field of action research (BERA, 2004). The aim of the guidelines is to enable educational researchers to weigh up all aspects of their research process when conducting an educational research within any context and to reach an ethically acceptable position in which their actions will be justifiable and sound (BERA, 2004). Additionally, BERA (2004) recognises that educational researchers aim to extend knowledge and understanding in all areas of educational activity and from all perspectives, which is what makes the community of educational researchers a multi-disciplinary one.

6. 4. 1. Informed Consent

In considering the ethical aspect of this research, informed consent is a major issue that should not be neglected. Much social research necessitates obtaining the consent and co-operation of the participants, who will assist the investigations, and of significant others in the institutions or organisations that provide the research facilities (Cohen, Manion & Morrison, 2007). According to Burgess (1989), informed consent refers to the voluntary consent of the individual to participate in research. BERA (2004) considers voluntary informed consent as the condition in which participants understand and agree to their participation without any duress, prior to the research getting underway. Additionally, Gregory (2003) strongly believed that consent is “one idea above all others” when talking about ethics of research involving live human beings (p.35).

Oliver’s (2003) opinion is that the feature of informed consent is a central one in social science research ethics and is the principle that wants the participants to be fully informed about the research project before they assert to take part. By fully informed he meant any information which the participant might conceivably need in order to make a decision about whether or not to participate. Of course, it cannot reasonably be claimed that people should have access to all possible knowledge but a right to information does exist and a way should always be found to explain the basics of the research project to the participants, in a manner they can understand.

The principle of informed consent arises from the participants’ right to freedom and self-determination. Informed consent is the procedure in which individuals choose to participate in an investigation after being informed of facts that are likely to influence their decision (Cohen, Manion & Morrison, 2007). For this study, this involved four elements:

- Competence, which implies that the individuals that make the decision are responsible and mature enough to make the correct decision when given the relevant information.
- Voluntarism, which entails the application of informed consent principle and, thus ensuring that participants freely choose to take part (or not) in the research and guarantees that exposure to risks is undertaken knowingly and voluntarily.
- Full information, which implies that consent is obtained after the participant has been fully informed, even if in practice, it is quite impossible for researchers to give information about everything, as this may affect the results of the study. When the data collection is completed, the participants are informed in more detail about the study and its aims.
- Finally, comprehension, which refers to the fact that participants fully understand the nature of the study.

It was also important for me to take the necessary steps as a researcher in order to ensure that all participants in the research understood the process in which they were to be engaged, including why their participation was necessary, how it would be used and how and to whom it would be reported. This study, which focuses on teachers, took all the above into consideration and prepared a sheet with information about the research that teachers should know in order to decide whether they wanted to participate or not. The information sheet was on the first page of the questionnaire and was also included in the interviews and focus group semi-structured schedule.

6. 4. 2. Morality

Taking morality into consideration in this study was seen as a necessity. Gregory (2003) sees morality as a social mechanism that helps humans to aim higher than they would have done otherwise. Morality is a “mix of character traits, sentiments, attachment to ideals, principles, rules of behaviour promoting and protective of the interest of other humans” (Gregory, 2003, p.28). The connection between morality and ethics is that morality is determined by values while ethics are codified rules deriving from morals. These values are varied depending on the time, the religion and the political regimes.

For this study, morality acted like a constraint upon the unconstrained pursuit of people’s private wants and ambitions. It is what reminded the importance of considering other people’s interests and concerns when thinking about how to act, what to say and what to do. Thus, the teachers’ personal interest and busy schedules were considered when planning the observations, interviews and focus groups. It also gave good reasons to act in a way that would not offend teachers at any time.

Morals are evaluated through logic, experience and proper judgement, whether these originate from culture, philosophy, religion, society or individual conscience. In a normative and universal sense, morality refers to an ideal code of conduct, one which would be espoused in preference to alternatives by all rational people, under specified conditions. Greig, Taylor and Mackay (2007) declared that researchers should always act in a moral way and they should not assume that being called researchers also allows them to act in a way which is not moral.

6. 4. 3. Privacy, Anonymity and Confidentiality

Privacy can be thought of as an individual's ability to seclude information about him/her. The boundaries and content of what is considered private differs between cultures and individuals, but shares basic common themes and it is sometimes related to anonymity, the wish to remain unnoticed or unidentified in the public realm, and confidentiality.

For this study, privacy was seen from three different perspectives. The first one was the sensitivity of the information given, which refers to how personal or potentially threatening the information that is being collected by the researcher is. The second one was the setting being observed, which can vary from very private (like the participant's house) to completely public. The third and last one was the dissemination of information which concerns the ability to match personal information with the participant's identity. Data which uniquely identify the individual providing them are labelled as personal data and when they are publicised, privacy is seriously violated.

Considering the above, this study recognised the participants' entitlement to privacy and also accorded them their rights to confidentiality and anonymity. Cohen, Manion and Morrison (2000) added that participants may sometimes choose to give up their right to privacy by allowing the researcher to access sensitive topics or by agreeing that the researchers may refer to them by their real name. In such circumstances, it is in the researchers' interests to have such a waiver in writing. However, under any circumstances participants were informed about how and why their personal data would be stored, to what uses it would be put and to whom it would be made available as a study needs to have participants' permission in order to disclose any personal information to others.

Other methods to protect the participants' privacy are anonymity and confidentiality. Anonymity is a cornerstone of ethics and it refers to the participants' right to keep their identity hidden in a research project (Oliver, 2003). The protection of the participants' anonymity was obligatory for this study and was fulfilled at all costs. As a result, information provided by participants was not exposed in any way that would reveal their identity. A participant can be considered as anonymous when another person cannot identify him/her from the information provided and this study ensured that (Cohen, Manion & Morrison, 2000).

The advantages of keeping the participants anonymous are numerous. One of them is that anonymity offered the participants a feeling of freedom to express their thoughts in an objective manner (Oliver, 2003). The anonymity freed them to express their true feelings. Also, anonymity encouraged objectivity through the research process and it protected individuals who might be mentioned by the research participants as it would be unfair for individuals unconnected to the original research project to be identified because they are included in a discussion by the participants (Oliver, 2003). Anonymity made it easier to explore issues which could be slightly unpopular or which were regarded as sensitive. This gave the ability to the researcher to explore sensitive issues since the participants were protected through anonymity. However, the participants did not always wish to take advantage of hidden identity and in those cases I respected this as well (Oliver, 2003).

Anonymity can be ensured with the use of various methods. In this case fictional names were used which were selected appropriately in a way that the authenticity of the research would not be lost. Since the anonymity was carried out carefully, there was no way any participant could be recognised but there are no absolute guarantees of anonymity, especially in the case of people who hold named posts. However, Oliver (2003) highlighted that the most essential issue is that researchers recognise the importance of privacy and anonymity for participants and do their best to ensure that privacy as far as possible. This is why the researcher tried to find a way to report ideas intended in an as balanced manner as possible.

Moreover, as it has already been mentioned, anonymity is not the only method to secure the participants' privacy. Confidentiality is also essential because it means that, even if the researcher knows who has provided information and they are able to identify the participants, she will not make the connection known publicly (Cohen, Manion & Morrison, 2000). Gregory (2003) recognises confidentiality as the appropriate response to the importance of privacy in human affairs, whereas Oliver (2003) sees it as the idea of privacy because it is something which researchers promise to participants and at the same time, as part of that promise, they inform participants of the key methods through which confidentiality will be ensured. Confidentiality is not the same with consent but it is part of the informed consent because consent will often not be forthcoming unless confidentiality can be guaranteed. Gregory (2003) noted that confidentiality is best assured on the basis of anonymising the collection of data.

The importance of the need for a researcher to be confidential is expressed through Oliver (2003) who said that the statements of confidentiality have to be regarded as a promise and need to be treated with all the seriousness which implies from a moral point of view. He added that the nature of the data that any research study will provide cannot be predictable and that is why the requirements of the law should carry precedence over promises in such situations.

Participants would not feel free to reveal their feelings, opinions or attitudes if confidentiality was not assured (Gregory, 2003). To ensure confidentiality, names, addresses or other means of identification from the data released on the individuals were well-secured and will be deleted after the end of the study. Also, crude categories were reported; for example, instead of releasing the year of birth rather than the specific date, asking the profession but not the speciality within that profession or questioning for general information rather than specific. In some cases error inoculation which refers to deliberately introducing errors into individual records while leaving the aggregate data unchanged was also used. Such techniques ensured that the notion of confidentiality was upheld. In closing this issue, it should be noted that anonymity and confidentiality are as important as ensuring that ethical principles are applied, which means examining the ethical implications of a study and ensuring that all ethical principles are upheld in the context of the particular research (Greig, Taylor & Mackay, 2007).

It is worth considering the possibility for participants to gain something from taking part in the research (Burgess, 1989). They are asked to give up their time and help, but usually the participants do not gain anything tangible from the research. The least that could be done was to structure the research process in such a way that participants both enjoyed it and found it interesting (Burgess, 1989). For example, the participants might not have any previous experience of social science research and might enjoy watching the way that the researcher approached the data collection process. Burgess (1989) noted that despite any responsibility the researcher might have in relation to informed consent, the process of participation could be made more interesting if respondents understood the background of the research.

The researchers always tried to maximise the opportunities for participants to personally gain something from the research. For example, the researcher encouraged the participants to arrive at a personal position on a number of complex issues. As Oliver (2003) commented, in this way the study would not be merely a one-sided process designed to help the researcher complete a research exercise, but rather a process of mutual help where the participants will achieve a certain level of fulfilment through the exercise of reason and reflection.

Participants, especially the ones that volunteer for a study, need to be allowed to discontinue participation. This study informed the participants of their right to withdraw at any time during the research process, and should feel free to do that, as it was part of the principles of their freedom and autonomy. Oliver (2003) explains that even when participants give their informed consent, they cannot anticipate whether they will find the experience enjoyable or stressful. That is why it was essential for the researcher to reassure the research participants that they may withdraw from the research at any time and they do not have to give any notice about withdrawal nor provide any explanation. Of course, there should be no penalties for not continuing and participants should not be brought under any pressure to continue (Oliver, 2003). However, no participants decided to withdraw from the study at any point, which indicates that the study did not cause any harm, distress, anxiety, pain or any other negative feelings to the participants.

6. 4. 4. Special Issues for Children

Internationally, the study of children is a wide interdisciplinary field and, over the last two decades, new theoretical perspectives have developed that focus on children as social actors (Christensen & Prout, 2002). Despite that, it is only within the recent decades that societies have come to appreciate and recognise that children have rights which are specific and which dictate that they should be consulted in matters that affect them (Greig, Taylor & Mackay, 2007).

Lewis and Lindsey (2000) outlined some ethical guidelines for research with children, which include the need for respect to a person's rights and dignity, competence (does the researcher know what he/she is doing?), responsibility (keep promises, role carry out) and integrity (adjust questions according to the audience and do not change the answers in order to get specific results). As a result, the researchers respected the research participants and the children were not included meaningfully in the decision-making process. It was the researcher's duty to ensure that the research would not be carried out on children unnecessarily and that the degree of intrusion would be minimal.

It is a fact that research involving young children probably requires more sensitivity to the power of relations than other kinds of research (Aubrey et al., 2000). The problem is that it may be impossible to inform young children fully about the research, so their consent may be more like exploitation. Even if this study does not directly involve children, parents were informed about the study and its implications. Parents and teachers informed children about the study and how this would affect them and their lesson and asked them if they felt positive about that. Children knew that they had a choice as to whether to participate in the research as true volunteers. Children, and their parents, also knew exactly what their role in the study was and they were informed about their right to withdraw at any time if they wished, without detriment to their care. However, no child expressed any wish to withdraw.

7. Analysis of data and Results

7. 1. First Phase of Analysis and the Results

The first phase of analysis includes the analysis of the questionnaires and the key informants' interviews. Firstly, the analysis and the results of the questionnaires are presented. This presentation is divided in three parts, based on the three parts that the questionnaire consists of. Secondly, the analysis and the results of the key informants' interviews are presented. In both cases, the use of tables and figures are seen as necessary to facilitate the presentation of the analysis and the results. A summary of the results is available at the end.

7. 1. 1. Questionnaire Analysis and Results

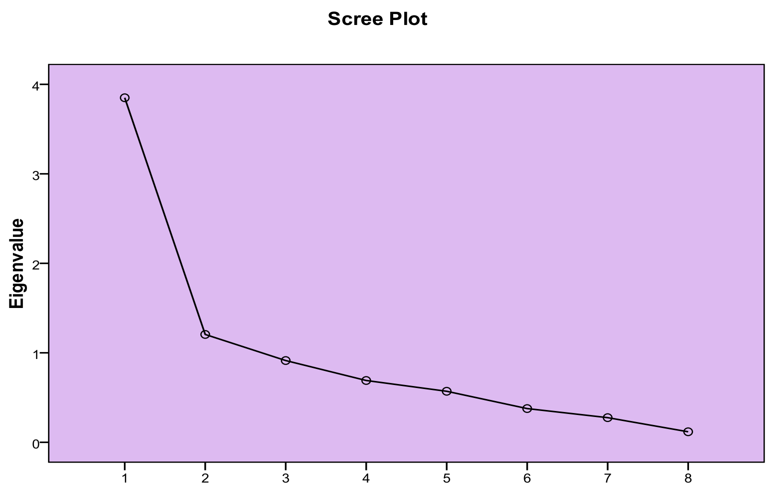
The questionnaire was sent to one hundred and thirty five (135) pre-primary schools, seventy five (75) of which were public kindergartens and sixty (60) were private kindergartens. The desirable response rate was calculated at 74%. To achieve this, at least 100 questionnaires should be returned in order to have enough to run the tests in the SPSS. Thankfully, the response rate was 77.78%, which is very good, as it is more than the desirable one. This means that one hundred and five (105) out of the one hundred and thirty five (135) questionnaires were returned. The questionnaires sent to public schools were returned through the prepaid-envelope method, whereas the questionnaires sent to private schools were collected through personal visits to all schools. A number of fifty five (55) questionnaires were sent back from the public schools and fifty (50) from the private schools. This might indicate that personal collections of the questionnaires can be more productive but it is also more expensive in relation to research time. All questionnaires were completed by female early-years' teachers which clearly indicates that the population is female dominated. This observation is also confirmed by the Ministry of Education since there is a list of all the names of the in-service early-years' teachers and a list with all the early-years' teachers waiting to get a job in public schools, 99.9% of whom are women (www.eey.gov.cy).

The questionnaire was developed in three parts and each was analysed with the use of different tests. The first part, which aimed to give a general idea of the population (gender, age, studies etc.), was analysed with the use of descriptive statistics. The second part was used to identify the reliability of the scale and the third part was used to make comparisons of the teachers' preferences. The last question, which was an open-ended one, was not compulsory and it gave the chance to teachers to add whatever they wanted. Thirteen (13) teachers, who were a percentage of 12.38%, answered the last question. This small percentage gave the opportunity to do the analysis of the responses manually, as it was possible to code them and group them into themes. More details on this will be given later.

The first step in the questionnaire analysis was to calculate the co-efficiency of internal reliability (Cronbach's Alpha). This could only be done for the second part of the questionnaire, since this was the part that included scale questions. Thus, the questions included in the second part of the questionnaire were the ones used to check the reliability of the scale. Cronbach's Alpha is a measure of the internal consistency or reliability usually used in psychometric tests. In this case, it is used to test the reliability of the questions by entering them in a simple test with the use of a statistical programme, SPSS.

Cronbach's Alpha can lie between zero (0) and +1. Any value over +0.7 is acceptable and indicates that the scale is reliable. In this case, Cronbach's Alpha was +0.823, with all questions included, which proves the reliability of the scale. Factor analysis extracted two factors. The following scree plot shows the two factors (point 1 & point 2) when all questions were included. When the question that affected the factor the least, which was school equipment since it had the lowest rate, was deleted, the Cronbach's Alpha was 0.834 and the new scree plot was very similar to the first one. Since the difference between the two calculations of Cronbach's Alpha was only 0.009, and after consultation with a subject-matter expert, there seemed no reason why to delete the 'school equipment' question, thus all questions were included in the analysis and it is considered that the scale used was reliable.

Tables & Figures 10*: Factor Analysis: The graph below shows the Scree Plot when all questions of questionnaire were included.*



7. 1. 1. a. Results deriving from the Questionnaires' First Part

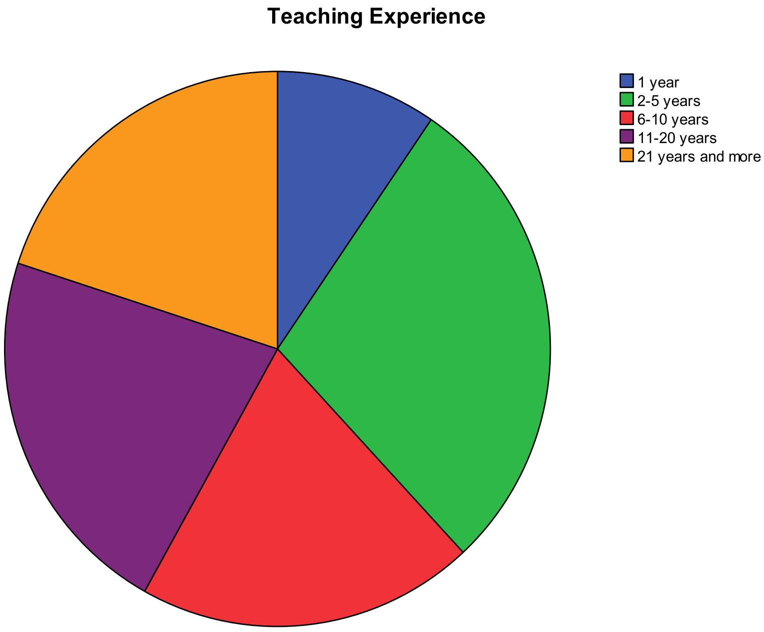
The first results that derive from the questionnaire aimed to provide some general information about the early-years' teachers population by analysing the questions included in the first part. The first analysis of the first question aimed to identify the subjects that early-years' teachers choose to study during high school, in order to find out what percentage chose to study 'science'. The results revealed that most early-years' teachers, specifically 38,1% (40 teachers), that completed the questionnaire answered that they had had a combination of subjects known as 'klasiko' and 23,8% (25 teachers) said that they had 'economico'. Only 12,4% (12 teachers) said that they had 'praktiko' and 25,7 % (27 teachers) chose the options labelled as 'other'.

All the teachers that selected 'other' did not have science as a main subject during high school either (they were asked to write the subjects that they studied and they did not include science in their list). As a result, a percentage of 87,6% teachers which selected klasiko and economico did not have science as one of their main subjects during high school. Only those that chose 'praktiko' were taught science as a main subject during high school, which means that only 12,4% of the in-service teachers that teach science today studied science during high school. This fact might raise questions about the implications that this might have when discussing the teachers' subject knowledge and their teaching of Natural Sciences, which will be further discussed in the next chapter.

The results also revealed that most early-years' classrooms had between twenty-one (21) and twenty-six (26) children. Specifically, 47,61% (50 teachers) that completed the questionnaire reported that they had fewer than twenty (20) children in their classrooms (from these 19 were public and 31 were private), 51,42% (54 teachers) had from twenty-one (21) to twenty-six (26) children (36 were public and 18 were private) and only one private classroom had more than twenty seven (27) children and this is considered an exception. These numbers suggest that private pre-primary schools usually have fewer children in each classroom compared to public schools, which is another issue to be discussed in the next chapter.

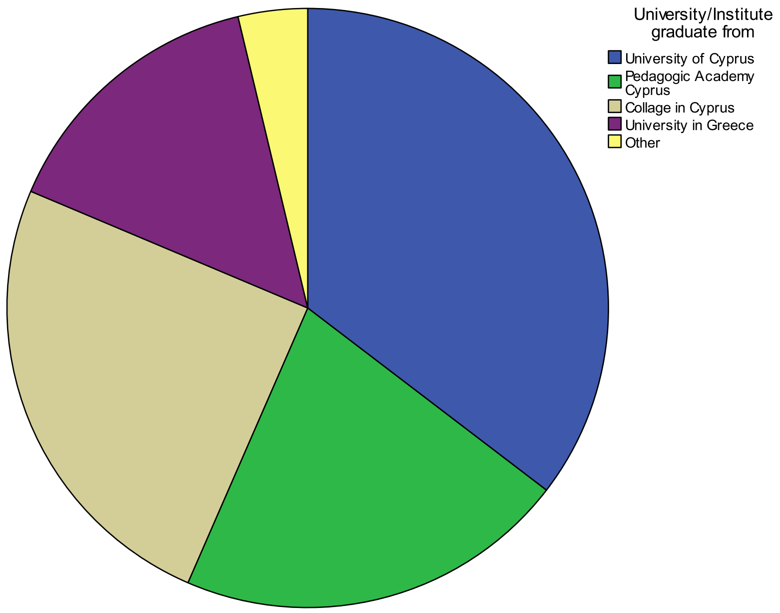
The following pie chart illustrates the years of teaching experience that the early-years' teachers have. It seems that most of the in-service early-years' teachers, 28,6% (30 teachers), have been working from two (2) to five (5) years. Additionally, 9,5% (10 teachers) had only one (1) year of teaching experience. Also, 20% (21 teachers) had from six (6) to ten (10) years of teaching experience, 21,9% of them (23 teachers) had from eleven (11) to twenty (20) years of experience and, finally, 20% of them (21 teachers) had twenty-one (21) years of teaching experience or more. However, when comparing private to public schools, it seems that the mean of teaching experience for public schools is higher than for the private ones. This might suggest that the early-years' teachers working in private schools are younger and with fewer years of teaching experience than the ones working in public schools.

Tables & Figures 11: Teachers' Teaching Experience based on the Questionnaires



The next pie chart gives information about where early-years' teachers usually complete their studies (institute/college/university). As the pie chart suggests, the most frequent answer was 'university' with 63,8% of the teachers reporting that they studied at the 'University of Cyprus' (27 teachers), which is the only public university in Cyprus, or at a private university/college in Cyprus (40 teachers). The third most popular answer was the Pedagogical Academy with 23,8% (25 teachers). Fewer teachers, 10,5% (11 teachers) said that they completed their studies at a University in Greece and only 1,9% (2 teachers) chose other as their answer. It is worth mentioning that all the teachers who studied at a private university (college) or at the Pedagogical Academy, were required to take some extra courses at the University of Cyprus after the completion of their studies, so that they would be allowed to teach in public schools.

Tables & Figures 12: Teachers' Place of Study based on the Questionnaires



7. 1. 1. b. Results deriving from the Questionnaires' Second Part

The statements included in the second part of the questionnaire were not only used to test the reliability of the scale, but also to make a comparison between private and public schools. This comparison was necessary in order to be able to determine if any important differences exist between the private and the public early-years' sector. To do this, the use of a t-test, which is used to compare two different groups (like private and public schools), was necessary. Since the two samples, private and public schools, are independent, the appropriate test to use was the one known as '*compare means – independent samples t-test*'[6] (when p<0.05 then fewer than 5 out of a 100 cases are spurious).

[6]The t-test assesses whether aiming of two groups are statistically *different* from each other. This analysis is appropriate whenever you want to compare the means of two groups. The formula for the t-test is a ratio. The top part of the ratio is the difference between the two means or averages.

The results of the t-test revealed that the teachers working in private schools have significantly higher scores ($t=2.295$, $p<0.05$) in regard to how satisfied they feel with the knowledge they obtained during their studies in comparison to the teachers working in public schools. Private school teachers also have significantly higher scores in regard to their satisfaction with the training they had within their studies ($t=2.350$, $p<0.05$), their confidence when answering the children's questions during a Natural Sciences lesson ($t=2.642$, $p<0.05$) and the satisfaction they feel about the equipment they are provided from the school ($t=3.047$, $p<0.01$, when $p<0.01$ then fewer than 1 out of 100 cases are spurious).

There were, however, some cases where the public and the private school teachers' responses did not differ. For these responses, the t-test did not reveal any significant differences between private and public school teachers, as the p value was less than 0.05, which means that less that 0.005% of the responses were significantly different. The statements that did not have significant differences between public and private schools are the following ones: 1) I believe that the lessons I had in secondary school affect my ability to teach Natural Sciences today, 2) I am confident about teaching Natural Sciences and 3) I like teaching Natural Sciences.

The following table provides information about the means and standard deviations calculated for each one of the statements. The mean is the sum of a series of observations divided by the number of observations in the series. It is used to describe the central tendency of variables. As noticed, for all scores that are significant (these are the ones with $p > 0.05$ or $p = 0.05$ and are indicated with

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The bottom part is a measure of the variability or dispersion of the scores. The answer to this ratio give't'.

a star * at the end of the statement) the mean for teachers working in private schools is higher in comparison to the ones working in public schools. The standard deviation is a measure of dispersion that is calculated based on the values of the data. It allows us to see how widely the data are dispersed around the mean[7].

Tables & Figures 13: Compare Means for each question for Public and Private school teachers

	Public		**Private**	
	Mean	**St. Deviat.**	**Mean**	**St. Deviat.**
I am confident about teaching Natural Sciences	3,60	0,807	3,76	1,061
I like teaching Natural Science	3,75	0,947	3,83	1,137
***I feel satisfied with the training I had during my studies**	3,04	1,186	4,00	0,990
***I feel satisfied with the knowledge obtained during my studies in regard to Natural Sciences**	3,13	1,187	3,66	1,189
***I feel that I was well-prepared to teach Natural Sciences when I finished my studies**	3,00	1,186	3,56	1,164
***I feel confident about answering**	3,56	0,938	4,02	0,820

[7] The standard deviation has the desirable property that, when the data are normally distributed, 68.3 % of the observations lie within +/- 1 standard deviation from the mean, 95.4% within +/- 2 standard deviations from the mean and 99.7 % within 3 standard deviations from the mean.

children's questions during a Natural Sciences lesson				
***I feel satisfied with the equipment I am provided from the school**	2,69	1,399	3,50	1,313
I believe that the lessons I had in secondary school affect my ability to teach Natural Sciences today	2,35	1,613	2,72	1,642

7. 1. 1. c. Results deriving from the Questionnaires' Third Part

The questions included in Part 3 of the questionnaire aimed to find out specific information about the teachers' preferences on the topics they teach in early-years' Natural Sciences. It was possible to correlate these responses with the use of correlation tests. A correlation is a single number that describes the degree of relationship between two variables. In this case, the variables included in Part 3 were imported and tested between them one by one. Specifically, these variables were: 1) How confident do you feel about teaching?, 2) How satisfied do you feel with your background knowledge?, 3) Please indicate how often you choose to teach the following topics., and 4) Please indicate the amount of preconceptions that children have in regard to the following subjects. These statements were repeated for each Natural Sciences topic as provided by the Cypriot National Curriculum and a scale was provided to enable the teachers to give their response. The topics were the following: Plants and Animals, Human Body, Weather-Earth-

Space, Ecology, Matter, Magnets, Light, Sound, Energy and Electricity (Ministry of Education, 1996).

For parametric data such as this one, which are based on normal distribution, Pearson's test is the appropriate test to use. The assumptions necessary to use this test were: 1) the sample data had to be normally distributed (which was) 2) the sampling distribution had to be normally distributed (which was) and 3) data had to be interval or ratio (which was) (Field, 2009). The results revealed that most of these variables are highly and significantly correlated, which means that there is a relationship between them when comparing each factor with one another. The level of significance is indicated by the value of Pearson's r that lies between -1 and +1. When $r = +1$ the two variables are perfectly positively correlated, whereas when $r = -1$ there is a perfect negative relationship. In addition, the p value indicates the significance of each relationship and, here, the most common significance level of $p > 0.05$ or $p = 0.05$ is used, which means that the odds that the correlation is a chance occurrence is no more than 5 out of 100 (ibid, 2009). The table with the values for 'p' and 'r' can be found in the appendices (see appendix 7).

In order to identify which of the factors are related, it was necessary to compare all factors with one another and check the significance of the correlation (p value). The significant correlations identified are the following ones:

- Positive Correlation (Pearson's r lies between $0 < r \geq 1$):
  - Teachers' satisfaction about their subject knowledge for each topic and their confidence when teaching that topic. (This relationship was observed for all the topics included in the National Curriculum.)

- How often teachers choose to teach each topic and their confidence when teaching that topic. (This relationship was observed for all the topics included in the National Curriculum.)
- How often teachers choose to teach each topic and what is the teachers' satisfaction about their subject knowledge for each topic. (This relationship was observed for all the topics included in the National Curriculum.)
- The teachers' opinion of the children's preconceptions about a specific topic and how often teachers choose to teach each topic. (This relationship was observed only for Plants & Animals, Magnets and Human Body.)

- Negative Correlation (Pearson's r lies between -1 and 0.00):
  - Teachers' confidence when teaching each topic and their opinion of children's preconceptions about that topic. (This relationship was observed for Plants & Animals, Human Body, Matter, Light, Sound and Energy.)
  - Teacher's satisfaction about their subject knowledge for each topic and teachers' opinion of children's preconceptions about that topic. (This relationship was only observed for Energy and Electricity.)

When talking about positive correlation, it means that, when one part increases, then the other part increases as well, so the two themes increase proportionally. On the other hand, when talking about negative correlation, we mean that the two themes discussed are diverse proportionally, which means that, when one part increases, then the other part decreases. Pearson's correlation test cannot give information about the kind of each relationship. It can only indicate the existence of a relationship.

The last question of the questionnaire was an open-ended question and gave the opportunity to teachers to add whatever they thought of relevance. This question was answered by thirteen teachers and, thus it was manually analysed with the answers coded into themes, grouped and similar themes merged. The result of this analysis is presented in the next table, which includes the themes based on the teachers' answers and how often they referred to each theme.

Tables & Figures 14: Themes deriving from the teachers' responses

Teachers' Statements	Number of Occurrence
Need better training/ more help/ more conferences	4
Experiments & Role Play can help in dissolving preconceptions	4
No need to work on preconceptions/ leave children's imagination free	3
Important for teachers to help children clear up their preconceptions	3
Need to check the children's concepts at the beginning of each new topic	2
Construction of knowledge based on the children's age	2
Teachers can create preconceptions through their teaching	2
Need for School Equipment	2
Good lesson planning can help to work on children's	1

preconceptions	
Teachers that like teaching Natural Sciences get more informed	1
Teachers have alternative concepts themselves	1

The results presented in the table above are very interesting since they indicate that early-years' teachers ask for more training and help concerning teaching Natural Sciences. They also reported the need for organising and participating in seminars and conferences on this subject more often.

Another interesting aspect of the above results is that three teachers recognised the importance of helping children overcome their preconceptions and two of them reported that it would be helpful to identify the children's concepts at the beginning of the lesson. The third teacher noted the importance of constructing knowledge based on the children's age. Another teacher specifically wrote that the children's concepts and preconceptions should be taken into consideration when planning a lesson since a good lesson planning can help dissolve the children's preconceptions. Two different teachers also identified the importance of being careful when teaching Natural Sciences and as one of them noted "Teachers can often pass their own alternative concepts to children through their teaching".

On the other hand, three teachers said that they do not believe that it is important to work on dissolving the children's preconceptions and one of them specifically noted that "We should leave the children's imagination free and not try to correct all their preconceptions". Two different teachers talked about the need for schools to be better equipped and supported the opinion that the lack of school equipment can make the teaching of Natural Sciences more difficult, especially the use of experiments. A teacher highlighted that the quality of a Natural Sciences lesson depends on each teacher, as she wrote “When a teacher likes Natural Sciences, she will be better informed and teach the lessons more effectively. Children will be more positive and excited about Natural Sciences, as well”. Finally, a teacher expressed the opinion that teachers have their own alternative concepts and they can pass them to children through their teaching; that is why she believes that “It is important for universities to include more science modules in the teacher qualification courses if student teachers are to gain more knowledge, have the time to eliminate their own alternative concepts and be well-prepared to teach Natural Sciences”.

7. 1. 2. Analysis and Results based on the Key Informants’ Interviews

In addition to the questionnaires, two key informants’ interviews were also conducted in order to collect further information about the training that student teachers receive during their studies. Emphasis was given on the student teachers’ scientific knowledge with specific reference to the children’s preconceptions. The key informants’ interviews were selected to give information in regard to these two areas that would mainly help to answer research question number 5: “What kind of training do early-years’ teachers receive about the children’s preconceptions?”

In order to analyse the answers that the two key informants gave during the interviews, the tape recordings were listened to carefully and transcribed.

Then, the main ideas that came out from the interviews were grouped and labelled. Finally, a group of colleagues were asked to listen to the tapes and have a careful look at the transcripts, the labels and the groups of ideas that were developed. They were asked to do this in order to ensure that different people, whose native language is also Greek-Cypriot, understand and translate the answers given by the key informants in English and in the same way. This would confirm that the translation was not biased and ensure the reliability and validity of the results.

7. 1. 2. a. Main themes deriving from the Key Informants' Interviews

During the analysis of the key informants' responses, a number of additional themes, which are presented in the following table along with quotes, came out. To secure the key informants' privacy, pseudonyms were used. The first key informant is called Mr Ken and the second one is called Mr Tom.

Tables & Figures 15: Main Themes deriving from the Key Informants' Interviews

Main Ideas that derive from the key informants' responses	**Key Informant No 1: Mr Ken**	**Key Informant No 2: Mr Tom**
School Equipment	All schools have the necessary specialised equipment but teachers usually find it hard to collect the non-specialised equipment they need for an	Early-years' teachers do not need any special equipment. They need to learn how to use materials that they can find anywhere and are also

	experiment	usually familiar to children
Curriculum	The national curriculum does not take into account the children's preconceptions similarly to the reference book that is used by the early-years' teachers.	The pre-primary national curriculum gives the impression that the children's education will end after pre-primary school and that they need to learn everything during that time.
Educational Reformation	The ideas and the changes that we try to apply in the Cyprus educational system are usually influenced by other countries.	The Ministry of Education decides what needs to change and the final changes depend on the minister and his advisers.
Selection of Topics	Most teachers choose to teach topics like "Plants and Animals" and "Human Body", which are simpler than others. In contrast, they seem to avoid topics like "Light", "Sound", "Electricity" and "Energy", which include more difficult concepts.	There are not easy or difficult topics to teach. A teacher's knowledge about a specific topic is what makes it easy or difficult to teach.
Teacher's Professional	The University of Cyprus organises a small number of	In Cyprus different universities offer a number

Development	conferences that teachers can attend. They can also attend seminars on different topics, organised by the Pedagogical institute in Cyprus although the seminars usually take place during the afternoons and the teachers need to sacrifice their personal time to attend.	of Master's. What is more, both the Pedagogical institute and the University of Cyprus offer different kinds of seminars.
Teachers' Training on Preconceptions	I always dedicate time to talk about the children's initial concepts and how these can create difficulties in practice. However, students do not have a specific assignment on the children's preconceptions.	I use the children's preconceptions to uncover the students' alternative concepts. Student teachers need to realise that if their subject knowledge is not sufficient, they cannot teach efficiently.
The Use of Reference Books	There is a reference book published by the Ministry of Education and is used by many early-years' teachers. The specific book though does not acknowledge the	All early-years' teachers use the same reference book and some of their lessons are an exact copy of those described in this book. Similarly to most books

	children's preconceptions. However, teachers are free to use any book they find useful.	available to teachers, unfortunately, this book does not make any reference to the children's preconceptions.
Identification of the Children's Preconceptions	Teachers can try to work with the children's preconceptions on a group level but I am afraid that most of them do not have the necessary skills and knowledge to do this.	I do not think that early-years' teachers identify the children's preconceptions because they do not think that it is important to do so. What is more, some early-years' teachers do not even know what preconceptions are.
Definition of the Children's Preconceptions	The children's preconceptions are "mini theories" that children construct based on their own experiences.	I would call them 'constructivist's approaches' because children decode the messages they receive based on their own experiences and they construct their own understanding.

Both Mr Ken and Mr Tom are professors in universities in Cyprus and both teach Natural Sciences. Thus, both have observed early-years' teachers during teaching and that is why they were asked to give their opinion about the topics that early-years' teachers choose to teach, based on their experience. Both identified "Plants and Animals" and "Human Body" as topics that are more frequently taught by early-years' teachers. In contrast, they said that early-years' teachers usually avoid teaching topics such as "Light", "Sound", "Electricity" and "Energy". As Mr Ken said "From my experience, teachers choose topics which are simpler than others and they seem to avoid subjects which include more difficult concepts. I am sure that these choices are mostly connected to fears that they have about their own background knowledge and not about the children's preconceptions on the specific topic." However, Mr Tom believes that the truth is that there are neither easy nor difficult Natural Sciences topics to teach. As he specifically said "It depends on how good background knowledge a teacher has about a specific topic to make it easy or difficult to teach. In other words, there are topics that a teacher knows and topics that he does not know."

One of the questions asked during the interviews aimed to collect information in regard to whether early-years' teachers identify the children's preconceptions or not. Mr Ken and Mr Tom both believe that early-years' teachers do not identify the children's preconceptions. Mr Ken explained that it is very difficult for teachers to work on the children's preconceptions on an individual level, especially when they have a class of twenty-five (25) children or more. He added that the big number of children in classrooms, in addition to the topics that need to be covered in a school year along with the limited time make it more difficult. Additionally, he explained that the books that are available to teachers are old and do not take into account the children's preconceptions or prior knowledge. As he said "Teachers can try to work on the children's preconceptions on a group level but I am afraid that most of them do not have the necessary skills and knowledge to do this."

Mr Tom had a different view and as he said "Early-years' teachers do not identify the children's preconceptions because they do not think that it is important to do so whereas some early-years' teachers do not even know what preconceptions are." He believes that the main problem is that early-years' teachers do not realise that some of the things that they believe are actually wrong and that they actually pass their own wrong concepts to children. He particularly said that "Early-years' teachers have some serious problems in regard to their subject knowledge." His explanation to this is that high school students in Cyprus take exams to enter public universities. Then, they study whatever they are assigned to, based on their score, instead of what they are really interested in.

Mr Tom considers teachers to be responsible for the children's preconceptions, but not in a direct way. As he explained, the responsibility lies on the educational system in Cyprus and the universities which do not give the teachers the necessary knowledge to be able to teach Natural Sciences. As he said "It is not the teachers' fault that they have alternative concepts themselves. My opinion is that the people who teach student teachers need to be experts in teaching approaches and not necessarily have a PhD in nuclear science."

In regard to the school equipment that is available to teachers, Mr Ken clarified that it can be divided into two groups: "Specialised equipment, like magnets, wires etc, which the schools have to provide the teachers with, and non-specialised, like cans, plastic or glass bottles etc, which are things that teachers and children can bring." As he explained, teachers usually find it hard to collect all the non-specialised equipment they need for an experiment. On the other hand, Mr Tom believes that early-years' teachers do not need any special equipment. As he specifically said: "They need to learn how to use materials that they can find anywhere and are usually familiar to children, as well. They do not need to do extreme experiments. They need to do simple experiments or models that will help children understand and construct their knowledge."

In addition, Mr Ken believes that the Cypriot national curriculum does not take into account the children's preconceptions, similarly to the reference book that is used by early-years' teachers. He also expressed the opinion that, with the educational reformation taking place now in Cyprus, the national curriculum will change and the books or some things in the books will change, too. He believes that "A lot of the things that are covered in early-years are also covered during the first grade of primary school and maybe it would be better to change the subjects taught at the early-year level."

Mr Tom agreed with this and he specifically said that the early-years' curriculum "gives the impression that the children's education will end after pre-primary school and that they need to learn everything during that time". As he explained, the national curriculum does not take into account the children's preconceptions and gives the impression that children are a miniature of adults. He pointed out the importance of giving time to children to construct their knowledge, something which is not taken into consideration by the National

Curriculum. He believes that “Time is necessary if we want to teach them the ‘scientific procedure’, which means teach them how to observe, collect data and think. Sometimes children do not understand concepts that are considered to be very simple, like the concept of gravity. We need to offer many different experiences to the children. We need to look at children individually because each child is different and learns in a different way.” Mr Tom thinks that the above will help the children to grow into independent adults who will be able to have their own opinion and voice in the Cypriot society.

Even if there was not a direct question about the educational reformation taking place now in Cyprus, both key informants chose to talk about this. Mr Ken recognises that it takes a lot of time and effort to make changes in regard to a country’s educational system. As he explained “Usually the concepts and the changes that we try to apply to the educational system in Cyprus are influenced by other countries, like the United Kingdom but by the time we are ready to actually try something new, other countries have already applied it and are looking for ways to improve it or change it again.” Mr Tom clarified that the organisation responsible for any changes in regard to education is the Ministry of Education. As a result, the decisions depend on each minister and his advisers. Similar to Mr Ken, Mr Tom also said that “The problem with Cyprus is that there are not specialised people that can do any kind of educational reformation. Whenever we try to change something, we copy other countries and we always fail. We only succeed in spending money. And I suspect that the same will happen this time as well”.

The key informants were asked to give information about the opportunities available to early-years' teachers for professional development. Both identified the University of Cyprus and the Pedagogical Institute as the main organisations that organise seminars and conferences which teachers can attend. As Mr Ken said "There are some science advisers, like myself. We visit schools and talk with teachers about new books and teaching methods but this is mostly for primary schools. Last year, we did something in regard to the children's concepts but we did not go into a lot of detail. These people suggest topics on which seminars can be organised each year, based on the teachers' needs". The problem that Mr Ken identified is that "The seminars take place during the afternoons and teachers need to sacrifice their personal time to attend." He suggested that the seminars should take place in working time to be easier for teachers to attend. In addition to this, Mr Tom talked about the professional development that early-years' teachers can have when studying for a Master's degree. As he said "There are different universities in Cyprus that offer a number of Master's that early-years' teachers can choose to study if they want to develop their knowledge, and I think that they should."

Mr Ken and Mr Tom were also asked to give information, and specific examples based on their experience, in regard to the training that early-years' teachers receive on the children's preconceptions. Both agreed that it is important for early-years' teachers to receive training in regard to the specific topic and both dedicate some time to do so through their own teaching at the universities. As Mr Ken said "I teach Natural Sciences in two universities and I always dedicate time to talk about the children's preconceptions and how these can create difficulties in practice.” As he described, his aim is to discuss conceptual change with his students. He also requires his students to include the children’s prior knowledge when they are assigned to design a lesson plan. However, he does not require them to submit a specific assignment on the children’s preconceptions.

On the other hand, Mr Tom uses the children’s preconceptions to uncover his students’ alternative concepts. As he said “I do not want students to feel that I accuse them of being wrong, so I use this strategy to make them realise on their own that some of the things that they believe are wrong.” As Mr Tom explained, he uses this technique to help student teachers to realise that when their subject knowledge is not sufficient, they can neither teach efficiently nor understand that knowledge is constructed rather than transferred from one head to another. As he specifically said “What I try to do is create a cognitive conflict that will make students realise that what they believe is wrong so that they will want to correct it. Then, teachers will be able to use the same method to correct the children’s preconceptions.” However, he believes that not all professors recognise the importance of this and, thus student teachers do not get the opportunity to investigate their own concepts. He particularly said that “There is not a specific module during student teachers’ studies aiming to help teachers to clarify their concepts and learn how to deal with the children’s concepts as well. Anyway, this cannot be done by one professor or in one lesson only.” This comment indicates the same issue about the teachers’ training that was also identified during the questionnaires’ analysis and it is worth discussing it further in the next chapter.

Since early-years’ teachers are not required to use a specific book when teaching Natural Sciences, the key informants were asked to give information about any reference books available to teachers. Both came to agree that there is a specific reference book which is published by the Ministry of Education and it is widely used by early-years' teachers. As Mr Tom said "All early-years' teachers use the same reference book and some of their lessons are a complete copy of those described in this book". As they both said, the problem with this book is that it provides teachers with examples of 'ideal' lesson plans which do not take into account the children's preconceptions. However, as Mr Ken said "Teachers are free to use any book they find useful. There are also primary books which include explanations about phenomena and concepts that can be useful for early-years' teachers if they want to get ideas and support their own subject knowledge." However, Mr Tom disagreed, as he thinks that most books available to teachers do not take into account the children's preconceptions, not even the ones used at primary schools. As he said "A lot of books give wrong information and are full of mistakes. That is why teachers need to be very careful in regard to what they choose to use."

The final question of the interview required the key informants to give their own definition of the children's preconceptions. In their definition, they both included the belief that the children based their concepts on their own experiences. Mr Ken defined the children's preconceptions as "mini theories" which children construct based on their experiences. As he explained, he chooses to call them "mini theories" because the children believe them for a reason and they can provide their own explanation.

Mr Tom used a different term and labelled them "constructivist's approaches" because, as he said, the children understand the messages that they receive based on what they experience in their everyday lives. He pointed out that it is important for teachers and adults in general to avoid making fun of children about their concepts because, as he said, "these concepts used to be scientifically accepted." At this point, Mr Tom highlighted that "Teachers need to understand that they themselves have some incorrect concepts in their minds and they can pass these concepts to children through their teaching. Teachers and children both need to realise that some of their concepts are wrong and this can be usually achieved through experiments. They also need to remember that learning should not end with the end of their studies. They need to learn how to investigate and be able to justify what they believe. What is scientifically accepted today might change tomorrow. What we need to teach children is how they can judge the information given to them and not just believe everything that somebody tells them."

Finally, Mr Tom said that "Children that have good early-year education are always good students. And this is a problem because in Cyprus we underestimate pre-primary schools and the value of the knowledge that children earn during their early-years. Imagine that pre-primary education became obligatory in 2000. Before that time, the different governments considered pre-primary schools to be a waste of money and not an investment like I believe it to be. Nowadays, it is even worse because teachers that finish their studies at a private university/college can get a job in schools and teach children. I have worked with teachers like these and I believe that they should not be allowed to teach."

7. 1. 3. Main Results deriving from the First Phase of Analysis

The analysis of the questionnaires and the key informants' interviews revealed some key areas that will be taken through to the next chapter for further discussion. Specifically, it is important to further discuss those themes that derive from more than one research collection method since the repetition of a theme signifies its importance. That is the reason for the use of different methods and for having triangulation. At this point, the main themes that need further discussion in order to answer the research questions are presented below.

7. 1. 3. a. Main Results deriving from the Questionnaires

1. Most in-service early-years' teachers, 87,6%, did not have science as a main course during high school.
2. Private pre-primary schools tend to have fewer children in each classroom compared to public pre-primary schools.
3. Most early-years' teachers, 28,6%, had between 2 to 5 years of teaching experience and 21, 9% had from 11 to 20 years of experience. Also, 20% had 21 years of teaching experience or more and another 20% had from 6 to 10 years of teaching experience. Only 9,5% of them had 1 year of teaching experience.
4. Most in-service early-years' teachers, 61,4%, reported that they have between 21 and 25 children in their classrooms (the maximum number of children per classroom based on the Ministry of Education is 25).

5. Early-years' teachers that work in private pre-primary schools tend to have fewer years of teaching experience in comparison to early-years' teachers that work in public schools.
6. Most in-service early-years' teachers, 63,8%, have completed their studies at the University of Cyprus or a private University/College in Cyprus.
7. Early-years' teachers that work in private pre-primary schools seem to feel more satisfied with a) their subject knowledge b) the training that they receive during their studies, c) the equipment provided by their schools and d) their confidence when answering to the children's questions compared to early-years' teachers who work in public pre-primary schools.
8. A positive correlation was identified between: a) early-years' teachers' satisfaction with their subject knowledge and their confidence to teach, b) early-years' teachers' topic preferences and their confidence when teaching that topic and c) early-years' teachers' topic preferences and their subject knowledge on that topic.
9. A negative correlation was identified between: a) Early-years' teachers' confidence to teach a topic and the teachers' opinion on the children's preconception on that topic and b) early-years' teachers' satisfaction with their subject knowledge about a topic and the teachers' opinion on the children's preconception on that topic.
10. Early-years' teachers are asking for more training, help and conferences about the children's preconceptions.

11. Early-years' teachers report that they usually use experiments and role play to teach Natural Sciences.
12. Three teachers said that there is no need to eliminate the children's preconceptions and, on the contrary, three different teachers emphasised the importance of dissolving the children's preconceptions.

7. 1. 3. b. Main Results deriving from the Key Informants' Interviews

1. The teachers' selection of Natural Sciences topics might be affected by the teachers' background knowledge/ studies/ alternative concepts.
2. Usually teachers do not identify the children's preconceptions because they might not have the necessary skills and knowledge to do this, they might not think that it is important to do so or they might not even know what preconceptions are.
3. The teachers' can pass their alternative concepts to children through their teaching.
4. The Cypriot pre-primary Natural Sciences national curriculum: a) does not take into account the children's preconceptions and b) gives the impression that the children's education will end after pre-primary school and they need to learn everything during that time.
5. The reference book used by early-years' teachers does not take into account the children's preconceptions.
6. Most student teachers do not receive any training about the children's preconceptions and they need to realise that when their subject knowledge is not sufficient, then they cannot teach Natural Sciences efficiently.

7. 2. Second phase of Analysis and Results

The second phase of analysis included the analysis of the face to face interviews, the analysis of the focus groups and the analysis of the observations. It also included the document analysis. Firstly, the analysis and the results that derive from the face to face interviews and the focus groups are presented together. This presentation is divided based on the free nodes and the tree nodes that the analysis gave with the use of the NVivo. This is further explained later. Secondly, the analysis and the results of the observations are presented and, finally, the results of the document analysis. Tables and figures have been used where necessary. A summary of the results is also available at the end of this part.

7. 2. 1. Analysis of Teachers' Interviews and Focus Groups

The five face-to-face interviews and the two focus groups (three participants in each group) give a total number of eleven participants (see table below). The responses from the interviews and the focus groups were transcribed and imported in NVivo and were treated in the same way, for analysis purposes, to enable identifying common themes between the responses. Even if importing the data in NVivo was very time-consuming, the use of the software saved time by helping in coding and finding themes in the data with the use of 'queries'. Using NVivo also enabled sharing the file with others when necessary (to exchange ideas or make comments), linking, annotating, and creating relationships between the themes that were created. These assisted the development of a better understanding of the data and, thus the analysis of the data and the report of the results.

The first step of the second phase of the data analysis was to identify the main themes of discussion during the interviews and the focus groups. To do this, the interviews and the focus groups were read thoroughly and notes about each participant were taken to allow the creation of a rough image for each participant. The information is presented in the next table.

Tables & Figures 16: Information on the teachers' portrait.

	Participation	**Years of Experience**	**Place of Study**	**Science Background**	**Attitude towards Natural Sciences**	**Studies about Preconceptions during studies**	**Ages in class**
T 1	Interview and observation	9	Un. Cyprus	Science during high school, Seminar	Positive	No	3-6
T 2	Interview and observation	25	Ped. Ac.	No science during high school, Seminar	Neutral	No	3-6
T 3	Interview and observation	25	Ped. Ac.	No science during high school, Seminar	Negative	No	5-6
T 4	Interview	8	Un. Cyprus	No science during high school, Seminar	Negative	No	5-6
T 5	Interview	31	Ped. Ac.	No science during high school, Seminar	Neutral	No	5-6
T 6	Focus Group 1 and observation	31	Ped. Ac.	No science during high school, Seminar	Negative	No	3-6
T 7	Focus Group 1	18	Ped. Ac.	No science during high school, Seminar	Negative	No	5-6
T 8	Focus Group 1	24	Ped. Ac.	No science during high school, Seminar	Negative	No	3-6
T 9	Focus Group 2	2	Un. Cyprus	Science during high	Positive	Yes	5-6

				school No seminar			
T 10	Focus Group 2	9	Un. Cyprus	No science during high school, Seminar	Positive	No	5-6
T 11	Focus Group 2 and observation	16	Un. Cyprus	Science during high school, Seminars	Positive	No	5-6

As shown in the above table, out of a total of eleven participants, ten were females and one was male, and had a mean of 15.8 years of experience. The teachers' years of experience can help to determine if there is a relationship between the teachers' years of experience and their attitude towards Natural Sciences, the training they had and the methods they use. Four of them graduated from the University of Cyprus, one from the University of Athens and six graduated from the Pedagogical Academy. Only three of them had science as a main subject during high school and all three expressed the opinion that this makes them feel more positive and more confident when teaching Natural Sciences and also that they have a positive attitude towards Natural Sciences. Similar to these three participants, one more participant seemed to have a positive attitude towards Natural Sciences whereas five participants seemed to have a rather negative attitude towards Natural Sciences and two participants seemed to feel neutral. All of them have attended a seminar on Natural Sciences apart from teacher 9 who has only had a two-year teaching experience. Finally, all of them teach Natural Sciences in the current academic year, four of them teach children from three to six years old and seven participants teach children from five to six years old.

7. 2. 1. a. Main themes deriving from Interviews and Focus Groups

The next step was to spot common ideas or differences between them in order to create the themes to code them. Themes here will be called nodes based on the NVivo programme. The first step was to create free nodes which are stand-alone nodes and useful while coding. The second step was to read them again and code the statements into the created nodes (by selecting part of the interviews or the focus groups and adding them into the free nodes). During this procedure[8], some extra nodes were created since there were statements that would not correspond to any of the free nodes that had already been created.

Then, some of the free nodes were changed into tree nodes, which give a hierarchical structure, since the specific free nodes needed to be organised to create categories and sub-categories. The hierarchy can help to organise the nodes based on their content and also to understand the relationships between the nodes. For example, all free nodes that talked about teaching methods, like ‘Role Play’, ‘Experiments’, ‘Groups’, ‘Models’ and ‘Videos’, were transferred into tree nodes under the label ‘Teaching Methods’, which means that role play, experiments, group work, use of models and videos, for example, are seen as teaching methods in order to facilitate the presentation of the results and the reader. Similarly, ‘General time’, which included information about preparing a Natural Sciences lesson in general, and ‘Teaching time’, which included information about how long a Natural Sciences lesson needs to last, went under the tree node labelled ‘Time Dedicated to Natural Sciences'. Everything that gave information about

[8] To create nodes you can go through the text and select words of phrases which have something important to say or you can do it without referring to the text, based on the research questions and guided by the literature review. It was important to keep a record of what the node represents, either as a comment or in a memo.

preconceptions, like ‘Identification’, ‘Response’, ‘When do you identify’, ‘Teacher’s Definition’, ‘Examples of preconceptions’, ‘Obstacles’, ‘Training’ and ‘What are preconceptions’ were transferred into tree nodes under the label ‘Preconceptions’. In a similar way, everything that gave information in regard to what topics teachers usually prefer teaching were transferred into tree nodes under the label ‘Teachers’ preferences’, along with the explanations that the teachers gave.

When the coding was completed, the nodes that were created were revised to make sure that nodes were not repeated. Additionally, nodes with fewer than two sources, which means that only one teacher talked about the specific theme, were merged with other nodes that referred to similar themes. In some cases, the label that was initially given to the nodes was changed in order to apply for both nodes that were merged. For example, the theme ‘Natural Sciences’ Corner’ had only one source, which means that only one teacher talked about the use of a Natural Sciences’ corner in her class. Since the specific teacher referred to the Natural Sciences’ corner as a method for evaluating the children’s knowledge, the specific node was merged with the theme of ‘Evaluation’. In the same way, the nodes “Revision’ and ‘Vocabulary’ were merged with ‘Summarising and Evaluating’, and the node for ‘Imagination’, which referred to the children’s imagination was merged with ‘Pre-Primary’, which included statements about pre-primary education in general.

7. 2. 1. b. Results based on the Free Nodes

The following list presents the free nodes that were created when the above procedure was completed. The first column presents the name that was given to the node, the second column is the number of teachers (sources) that referred to the specific node and the third column gives the number of times that there was a reference to the specific node.

Tables & Figures 17: Free nodes: The main themes deriving from the interviews and the focus groups

Name of Free Node	Number of Sources	Number of References
Predictions	3	9
Summarising & Evaluating	3	10
School Equipment	3	6
Water Cycle	4	9
Pre-Primary	7	21
Attitude	7	13
Lesson Plan	7	16
Resources	7	29
Colleagues' Advice	7	15

The first free node with three sources (teacher 4 and focus groups 1 and 2) and nine references is 'Prediction', which refers to the activity of predicting what will happen and it basically involves the children and the teacher in a discussion about the possible results of an experiment. According to the teachers, it is very important for each Natural Sciences lesson to begin with a discussion-prediction part that will help the teacher to identify the children's prior knowledge and preconceptions. Then, the children try different things and experiments. The lesson needs to end with another discussion that will aim to summarise the lesson and find out if their predictions were correct. Teacher 9 specifically said that "This is why we do the experiment and in the end we discuss and see if they predicted correctly because that is when they will realise by themselves that what they thought was wrong." The teachers also referred to this procedure as time-consuming but still very important, and as teacher 9 said "It is better to just cover five topics and do them well and make sure that children have learnt what you want them to learn, rather than cover 15 and just pass them very briefly".

'Summarising & Evaluating' follows with three sources (focus groups 1 and 2 and teacher 5) and 6 references. This node includes statements that refer to different methods that the teachers use to summarise the lesson and/or evaluate what the children have learnt. For example, teacher 8 said "We do the discussion at the beginning of the lesson and we sometimes do something at the end, as well, like a drawing or colouring to see what the children know." Similarly, teachers 6 and 7 talked about giving a definition with the children at the end of the lesson which can help to find out whether the children have understood the lesson or not and it can also help to practise using the correct vocabulary. Finally, teacher 11 said that revising is also very important and helps children to understand in more depth and also remember what they have learnt during the year. As she said, having a 'Natural Sciences' corner' in the classroom can help with revising since "Teachers can put the results (from activities and experiments) in the 'Natural Sciences' corner'. The children go there very often and when visitors come to the class, the children take them there to show them and explain what they have learnt."

'School Equipment' comes next with 3 sources (teachers 2, 3 and 5) and 6 references. The teachers agreed that the use of materials in a Natural Sciences lesson is very important since the children learn through their senses and need to see, touch, smell and taste different things and experiment, discover and learn. According to the three teachers, the fact that their schools do not have all the necessary equipment and just have some basic materials is a big obstacle when teaching Natural Sciences. In fact, teacher 2 said that "This is the problem with Natural Sciences (the lack of equipment) and this is the reason I have not taught electricity so far because I do not have the necessary materials."

However, teachers 3 and 5 both agreed that teachers can find or buy materials themselves and they can also ask children and parents to bring the materials from their houses. Teacher 5 said that each school needs to have equipment and materials for Natural Sciences but, unfortunately, most schools only have some basic materials (e.g. mirrors, magnets). As she pointed out "The government gives money to each school and the headteachers can use the money to buy the necessary equipment for their schools, for each Natural Sciences lesson. It is up to the headteacher and the teachers to look for and find what their school needs, since they have nobody to guide us. There are a lot of things in the shops that teachers can use".

The free node of 'Water Cycle', with 5 sources (teachers 1, 2, 3, 4 and 5) and 11 references, includes everything that refers to what the teachers said in regard to how they usually teach the 'Water Cycle'. All of them said that they use the Reference book for guidance and that they usually begin with a story or a fairy tale. Teachers 2 and 5 added that they prefer to start the lesson with an observation and they make it look like something that happens by luck or ‘accidentally’. For example, they ask the teacher assistant to prepare tea and ask the children to observe and report the procedure. They use questions to help the children, like “What did the teacher assistant put in the kettle?”, “Do you hear anything? What is that sound?”, “What is that thing coming out from the kettle?”. According to what teachers said, the example of boiling water in a kettle is very often used, either at the beginning or in the middle of a lesson.

Teacher 5 said that it is important to use examples and experiments to offer experiences and opportunities to children to discuss with them and listen to their ideas. These kinds of discussion can begin with examples like the boiling water in the kettle, wet clothes and how to dry them, ice cream that melts, water ponds after a rainy day, and they can lead to predictions which will be validated or invalidated and lead to a conclusion.

The next free node with 7 sources (all teachers) and 13 references is ‘Attitude’, which includes statements that indicate how early-years’ teachers feel about teaching Natural Sciences. While analysing the specific statements, one can easily identify those statements that are positive and those that are negative. Specifically, four out of the thirteen references indicated a positive attitude towards teaching Natural Sciences, five indicated a negative one and two of them were neutral since they had a sign of both a negative and a positive attitude towards teaching Natural Sciences.

The positive statements included phrases like “I like teaching Natural Sciences more than other lessons”, “I enjoy teaching Natural Sciences”, “I teach Natural Sciences with excitement” and “Natural Sciences is one of the most interesting subjects to teach”. On the other hand, the statements that indicated a negative attitude towards Natural Sciences included phrases like “It is difficult to teach Natural Sciences and manage everything especially when working in groups”, “I feel that there is a feeling of fear about this subject” and, finally, “I do not feel very confident. I feel a bit scared”.

The two statements that indicated both a negative and a positive attitude included phrases similar to the above positive and negative ones. For example, one teacher specifically said “When a teacher likes a topic, then she will teach it with excitement and the lesson will be better. So, when you do not really like something, it might be better to ask a colleague to do it instead of doing it and passing this negative feeling that you might have to children.” Similarly, another teacher expressed the opinion that “When you like a subject, it means that you are interested in that and you get informed and you know more things. And, if somebody does not know a specific topic well, with regard to subject knowledge, then, they believe that instead of doing it and create knowledge gaps, it would be better not to teach it at all. There is some kind of insecurity when teaching Natural Sciences.”

‘Colleagues’ Advice’ comes next with 7 sources (all teachers) and 15 references, which include information about how teachers can help or advice each other in regard to Natural Sciences. Four teachers, specifically teachers 2, 5, 7 and 11 expressed the opinion that it is very helpful to discuss Natural Sciences with other colleagues and get advice and new ideas on how to teach something. Teacher 2 also found the opportunities to frequently observe other teachers while teaching very important because as she said “observing other teachers teaching is an experience that can help you improve your teaching and at the same time you can help a colleague with your advice, as well”.

On the other hand, teachers 1, 3 and 4 said that they never had any help from their headteachers or from other colleagues since they felt that their colleagues had nothing to offer them in regard to Natural Sciences. Specifically, teacher 4 said “I did not have the opportunity to work with people that had something to teach me. I would contact someone if I knew that they have been to a seminar, or have a Master’s degree or something else relevant to Natural Sciences but I have not met anyone like that. Anyway, there is a kind of mystery in pre-primary schools and it is not easy to observe a colleague teaching because she may not like it or the headteacher may not agree etc. There is a fear that the comments they will receive will be negative.”

‘Lesson Plan’, with 7 sources (all teachers) and 16 references, is the next node that included information in regard to how teachers plan a Natural Sciences lesson. All teachers agreed that each Natural Sciences lesson needs a good beginning that will capture the children’s interest. Teacher 10 noticed that to do so, it is also important to choose topics that children will find interesting based on their experiences.

According to what they said, a good beginning for a Natural Sciences lesson can be a problem that needs to be solved by the children (teacher 10), an observation of something that happened, like water boiling in the kettle (teacher

8) or a story/fairy tale (teachers 1, 9 and 11). Teachers 9, 10 and 11 specifically said that they usually start their lesson with a problem and ask the children to help them find a solution. Then, the children make suggestions on how to solve the problem and make predictions about what will happen. Then, the class is divided into groups and the children experiment to find the answer to the problem through organised activities. The lesson ends with a discussion on what they did, like a summary, and suggestions about the best solution to the problem. Teacher 11 highlighted the importance of giving a chance to all children to participate in the activities because it is important for the children to experience what they learn and try and do things instead of watching. Teacher 5 agreed with this and added that the final activity needs to evaluate what the children have learnt during the day.

'Pre-Primary Education' is the next free node on the list with 7 sources (all teachers) and 21 references. This free node includes all the teachers' statements with regard to pre-primary education, like the curriculum, the aim of pre-primary education and the teachers' freedom to choose what they want to teach. In regard to the aim of the pre-primary school, there is a contradiction between the teachers' opinions. Teacher 6, 7 and 8 that participated in the first focus group agreed that the aim of the pre-primary school is to help and guide the children to develop their skills (e.g. observation skills) and not to change or correct their preconceptions. However, teacher 5 stated "Since 2004, we have been teaching skills and Natural Sciences aiming at helping the children understand concepts and conquer skills and experiences about the world around them", which indicates that Natural Sciences is about both skills and knowledge.

Teacher 8 actually said that “Children use their imagination and we cannot take their right to imagine because it is a characteristic of their age. When they grow up, they will understand what is correct. It depends on how mature they are. The main aim of the pre-primary school is not to change these concepts; they will come back to them at primary school and high school”. Teacher 7 came to agree and said “I agree because pre-primary education is more about helping children use their imagination and it is not a main target to eliminate all their preconceptions”. Finally, teacher 6 believed that teachers can ignore children which have preconceptions. As she said, “Anyway, not many children leave school with preconceptions. If it is a lot of children, then it is the teacher’s fault. Maybe it was the wrong time to do it or the wrong method. You can ignore it only if it is a small percentage”.

In contrast, teacher 11, who participated in the second focus group, disagrees with this opinion, since she believes that pre-primary education is the basis for the children’s future education. As she explained, with the use of the appropriate methods, children at this age learn things that will be part of their knowledge for the rest of their lives and they will not forget them by the next day. As she stated “This is the aim of pre-primary education; to teach children something that will help them in their everyday lives and enable them to use the things that they learn in different cases and settings.” The same teacher believes that it is better to cover fewer topics and use the correct and, possibly, more time-consuming methods, instead of going through more topics but not covering them in depth in order to save time.

As it has already been said, based on the pre-primary Cypriot National Curriculum, teachers are free to choose the topics that they want to teach and the time that they want to devote on each topic and on Natural Sciences in general. Teachers 3 and 6 both agreed that having this kind of freedom is good and specifically teacher 3 said that “One of the positive things in pre-primary school is that we do not have to teach specific topics, so when we do not really like something, we are not obliged to teach it; we can just do some simple things on that so that we will not ignore it completely, but we will not devote a lot of time on that”.

However, teacher 5 disagreed and as she said “This freedom that we have can damage Natural Sciences because some teachers choose not to teach it at all, even if the curriculum says that all subjects must be taught. I think that the curriculum should be stricter”. Teacher 1 agreed with this and also believed that the Cypriot Curriculum should have different topics. For example, as she said “Electricity is something that should be covered in pre-primary science education. But, of course, we are not obliged to teach all the topics that are included in the curriculum. We are free to choose what we want to teach and how often.”

‘Professional Development’, which includes statements with reference to the teachers’ professional development, such as attendance to seminars, conferences etc., comes next with 7 sources (all teachers) and 23 references. All teachers, besides teacher 9, have attended some kind of seminar in regard to Natural Sciences. According to the teachers, the seminars are very helpful because they give them the opportunity to discuss with colleagues, listen to other teachers’ experiences, and get informed about new methods, materials and different ways to teach a topic. These seminars are organised by 'POED', i.e. the Cypriot teachers' organisation, or by the Pedagogical Institute. However, all teachers expressed the need for more seminars and conferences to be organised during their working hours, because only then will teachers be able to attend. Seminars need to be more often organised as well, because as teacher 4 said "I have been to a lot of seminars but I do not remember anything now. We need to have seminars more often". Finally, only one of them, teacher 4, continued their studies to achieve a Master's degree in Educational Leadership.

Teachers 2, 3, 5, 6, 7, 8, and 11 were the ones that attended the seminar which aimed to inform all the in-service teachers about how to use the reference book to teach Natural Sciences. Teachers 1, 2 and 9 also attended a different kind of seminar for Natural Sciences, which was not obligatory and lasted 2 days. As teacher 1 said "It was more theoretical, almost nothing had to do with the children's understanding. We talked about which topics are better to be taught at the end of the year and which at the beginning and how we can do more things with those children that are able to do more. But we did not do anything practical. Everything stayed in theory". Finally, teachers 2 and 7 talked about visiting schools and observing teachers while teaching. This was once organised by their school inspector and, as they said, it was very helpful to discuss and exchange ideas with other teachers.

'Resources' is the last free node, with 7 sources (all teachers) and 29 references, and includes information about the resources that are available to teachers and the ones that teachers use to teach Natural Sciences. All teachers said that their basic resource to teach Natural Sciences is the 'Reference Book for Pre-primary Education', written by a team headed by Dr. Konstantinos Konstantinou (Nicolaou & Kiriakidou, 2004). All teachers agreed that this book is very useful and covers a number of Natural Sciences topics that are taught in pre-primary schools, but they still need more books and more resources to support their teaching.

Teachers also agreed that they are free to choose from a variety of books and they are free to use any other book or resource they want or find useful. As teacher 6 highlighted "Things are much better today in comparison with how they used to be because now we have a lot of shops from where we can buy books and computer programmes, and we can also use the Internet where we can easily find information about everything". Teacher 2 said that she sometimes uses primary science books to find information or improve her subject knowledge and teacher 8 referred to some other reference books and gave specific examples: 1) "Science experiments at pre-primary education" written by Aggeliki Thanu and 2) "Experiences and Activities in Natural Sciences" written by Lazaro Gavala and F. Lavrentaki Mpuka. Still, as she said, these are Greek books and they might not be very helpful because the way that Natural Sciences is taught in Greece is different from the way that Natural Sciences is taught in Cyprus and they do not make any reference to preconceptions either. However, she believed that teachers can take useful ideas from these books which they can adjust in their lessons.

Teacher 5 was a member of the team that wrote the Reference book for pre-primary education. As she said "A number of teachers participated in the programme and frequent meetings took place for the book to be written. The teachers taught and tried things in their classrooms and reported the results back.

That was when I realised what science is all about and I started teaching science and not something else. Before that, teachers did not know how to teach science. After that, all teachers attended seminars specifically on how to use the Reference Book, teach Natural Sciences, and understand what science in early-years should be about. The book was the basis for this knowledge. Now, I believe that all teachers can teach Natural Sciences with the help of this specific book. It may not cover all the topics but it has references that you can use to find more information if you want. Since then, things have improved and especially young teachers that graduate from the University of Cyprus are a lot better than the ones that have graduated from the Pedagogical Academy because when we were students, they did not give us the necessary knowledge for science". In regard to this, teacher 2 also said that before the Reference Book was published, she was unsure about how to teach Natural Sciences but now her Natural Sciences lessons are very similar with the ones described in the Reference book.

6. 2. b. Results based on the Tree Nodes

The next list presents the tree nodes and, similar to the free nodes table, the first column presents the name that was given to the node, the second column is the number of teachers (sources) that referred to the specific node and the third column gives the number of times that there was a reference to the specific node. The nodes which are written with bold letters are the tree nodes and the ones below them are the child nodes and this signifies the hierarchical order. The child nodes are under the tree nodes in hierarchy and each child node has some information to add that further explains the tree node.

Tables & Figures 18: Tree nodes: The main themes deriving from the interviews and the focus groups are hierarchically presented

Name of Tree Node	**Number of Sources**	**Number of References**
Teaching Methods		
Experiments	7	15
Role Play	5	7
Groups	1	2
Model	1	1
Video	1	1
Preconceptions		
Examples of Preconceptions	7	11
Identification	7	24
Obstacles	7	14
Prior Knowledge or Tabula Rasa	6	8
Response	7	20
Training	6	17
What are Preconceptions	6	18
When do you Identify	5	5
Teachers' Definition	6	16
Teachers' Topic Preferences		
Confidence to teach	1	2
• Human Body	2	2

• Magnets	1	1
• Materials	1	1
• Plants & Animals	2	3
• Water Cycle	4	7
Do not like teaching		
• Electricity	3	4
• Light-Shadows	1	1
• Magnets	1	1
Usually teach		
• Magnets	1	1
• Mirrors	1	2
• Plants	2	3
• Water Cycle	4	6
Why these topics	6	10
Time Dedicated to Natural Sciences		
• In General	7	18
• Teaching Time	5	12

7. 2. 1. c. 1. Teaching Methods

'Teaching Methods', which is the first tree node presented in the above table, includes the different methods that teachers referred to when they were asked to identify the methods that they find more appropriate when teaching Natural Sciences. Most teachers (teacher 4, 6, 7, 8, 9, 10 and 11) identified

‘Experiment’ as an appropriate method to use when teaching Natural Sciences but only three of them actually said that they sometimes use this method. These teachers expressed the opinion that experiments can help children to experience and, thus better understand what they are being taught. Teacher 11 also said that “It is true that children like it and, even children whose first language is not Greek like it, because it is not only about understanding the language for the specific subject, as they can see and experience things”.

Additionally, teacher 7 said that “My advice would be to use experiments, because when children experience something through their senses, then they will believe it and learn it. It is very important for children to live and experience things, so we need to use experiential learning”. Teacher 6 added that “Teachers have to avoid dangerous experiments and also avoid doing everything in much depth because children might get bored. They do not need all the details. If a teacher notices that the children are not interested anymore, it would be better to stop and not take it in more depth and try to do something else”.

As indicated by the numbers in the table, five teachers (teacher 1, 2, 8, 9, and 10) said that drama, role play and theatrical games are appropriate when teaching Natural Sciences. Specifically, teacher 9 said that “In some cases, where experiment cannot be used, like when you want to show the electrons’ movement in a circuit, you can use role play which is also very helpful. For example, they hold hands and transfer the movement from one to the other and if the circle breaks somewhere, then the movement will stop”. Similarly, teacher 10 said that she usually uses role play when teaching the ‘Water Cycle’: “Children are water drops and we have a big picture of the Sun. Children-water in the sea get hotter and hotter and they pretend to feel dizzy and, then, they start rising and going up to the sky".

'Group work' was not so popular since only teachers 9 and 10 talked about using group work. Actually, teachers 9 and 10 both said that group work can be helpful but can also prove to be difficult to use and as teacher 9 reported "Working in groups can be very helpful but it can also be very dangerous. If the teacher is not careful, then the strong child in the team might take control and not let others try and might convince the rest of the team for something wrong. The teacher's role is more coordinative". Teacher 10 added that "Teaching in groups is another thing that makes Natural Sciences a difficult subject to teach as it is very hard to have groups in the class and manage to follow what everybody is doing and control everything that is going on".

On the other hand, only teachers 4 and 9 referred to using "Models' and "Videos', respectively. Teacher 4 explained that the use of models can be useful, like using a globe ball, but as she said, children cannot always make the connection between the model and real life. For example, some children will not understand that the globe ball is a model of what we are actually standing on at the moment and as she said "they might think that it is something irrelevant to them". Similarly, teacher 9 said that he uses videos when he wants to teach plants and animals and he believes that "Teachers have to use all kinds of resources and technology like 3D Videos when there is an educational value and children will be helped and not just do it". Here, it is worth explaining that with the term 'Models' we refer to the analogies, metaphors, pictures or objects that teachers might use to explain something that children are not able to actually see (Bamps & Claeys, 2011).

7. 2. 1. c. 2. Preconceptions

The next tree node includes everything that was reported about ‘Preconceptions’. Firstly, each teacher was asked to give one example of the children’s preconceptions for the ‘Water Cycle’. The next table presents the example that each teacher gave.

Tables & Figures 19: Teachers’ examples of the children’s preconceptions for the ‘Water Cycle’

Teacher 1	Children believe that water is white and you have to put a glass of milk next to it for them to realise that it is not white. They really believe that it is white.
Teacher 2	They always say that steam is smoke; they might say that a cloud is crying when it is raining, especially when there is something like that in the fairy tale. But, I think most children, especially 5-year-olds, know that this is not true and that it is just part of the fairy tale language, even if they use it. They also say that clouds crash, which is partially true, and also that God sends rain, which I also believe that it is true but you want them to tell you the physical phenomena. You have to accept everything that they say.
Teacher 3	They believe that ‘It is raining because God is angry’

	especially when it is thundering.
Teacher 4	Children believe that it is raining because the clouds are crying.
Teacher 5	One example is that clouds crash and we have rain or that God is angry and we have rain. They did not have the chance to be puzzled and think about this phenomenon, so what they believe is wrong because that is what they think or somebody told them something.
Teacher 6	They might not accept that water evaporates because as they say that they ‘cannot see it’.
Teacher 7	We put a glass of water outside the classroom and a few days later we see that there is no water anymore in the glass. When I ask them what happened to the water, where did it go, they usually say that some kind of animal took the water (laughs) and sometimes they might say that the teacher assistant took it. They do not realise that water evaporates.
Teacher 8 (She went outside and asked some children ‘What happens when it rains?’ because she did not know what to write).	A child told me that thunders come on clouds and then it rains. A couple of children told me that it is raining from the clouds which is correct and it is strange because we have not done anything on the water cycle so far.

Teacher 9	My example is with evaporation and specifically with the salt lake in Larnaca, called Aliki, that some children insisted that all the water is absorbed by the soil. They do not realise that a big percentage of the water evaporates.
Teacher 10	What they told me once is that ice will only melt if we put it outside in the sunshine and they thought that if I have ice but somewhere without sunshine or somewhere inside, then it will not melt.
Teacher 11	This year, when we did the 'Water Cycle', it started raining during the break and some children believed that we caused the rain because of the steam that we created in the class during the experiment.

During the interviews and the focus groups teachers also discussed the importance of identifying the children's preconceptions. All teachers agreed that it is important to have an activity at the beginning of each lesson aiming to identify the children's preconceptions. Some of them, though, confessed that sometimes teachers do not have such an activity, even if they admit its importance. Specifically, teacher 2 reported that "I think that it would be good although I do not do something to identify these preconceptions; yet, more or less, I know their concepts from what they say inside and outside the classroom. From my experience I usually know what children at this age and this area think".

However, teacher 11 added that sometimes teachers assume a certain basis of knowledge for all children and, also, that children know something when they actually do not. As she said “It has happened a lot of times to me as well when I start teaching a topic. I assume that children know something and then I realise that they do not. I would say that it is better to always have an activity that will aim at discovering the children’s prior knowledge before starting the lesson, no matter how well you know your class, just to be on the safe side.” Teacher 9 agreed and as he said, a teacher can sometimes begin without knowing the children’s preconceptions and have a successful lesson. Yet, this can only happen when the teacher is continuously on alert and is listening to what the children say all the time. The teacher also has to know where each preconception derives from because only then she will be able to eliminate it.

As teacher 10 described, her lesson includes a prediction-discussion part which is how she uncovers the children’s prior knowledge and preconceptions. As she continued “If you do not uncover the children’s preconceptions, you will begin you lesson with the wrong bases and there are two cases. The first case is that you will have a lesson without a point because children will already know what you are teaching, so it will be a waste of time. The second possible case is that children will not be able to follow what you say and the lesson will not have something to offer them because they will not understand what you say.”

According to the teachers, even when having an activity that will aim at uncovering the children’s preconceptions, it is not possible to know everything that the children have in their minds. Usually, when children believe something, they will say it because they tend to show what they know. Teacher 11 had an experience when a child expressed a preconception during the lesson. She thinks that, in such a case, the teacher should stop the lesson and work on the specific preconception that was uncovered because other children might have the same preconceptions, as well. As she said "I always deal with preconceptions that come up during the lesson and this might take a few minutes or a number of lessons, depending on the preconception. And I do that because usually it is not only one child that has that preconception."

Teacher 9 agreed that it is very important for the teacher to stop the organised lesson and do something to deal with the preconception that has been uncovered. He gave the following example: "When I was teaching 'Sinking and floating', during the lesson one child strongly insisted that wood does not sink, based on his experience that boats are made of wood and they float. I asked him to put a piece of wood in the water and the wood sunk. The child still insisted that wood does not sink! And I told him 'But you have seen it, it did sink' and he insisted that wood does not sink. Of course, the point of the lesson was to see which materials sink and float, but also take it further in regard to the shape of the material, so I could not ignore this preconception." As he explained, he insisted with more examples and further discussion until the child was fully convinced.

Teacher 10 also advised other teachers not to ignore the children's preconceptions and "even if it is only one child that expresses the preconceptions, teachers still need to work on it." Teacher 11 added that from her experience, teachers often ignore preconceptions that are expressed during a lesson because they do not have the time or because they have prepared and organised a different lesson.

Teacher 1 also shared her experience; a preconception was expressed during a Natural Sciences lesson and as she described “It was not interrupting the learning procedure but I felt that I was ignoring my students, who they are and what they know. You cannot start a lesson and ignore who you are teaching and what they know, what experiences they have. You need to know their preconceptions in order to build on what they know. They are not tabula rasa; they come with a lot of unorganised knowledge and teachers need to understand this.”

Based on the above, teachers believe that they need to be aware of the children’s preconceptions to have successful lessons. All teachers agreed with this but only four of them said that they actually do it (and maybe not always). The specific teachers also believed that, in the case of uncovering a preconception during the lesson, even if there was already an activity at the beginning of the lesson which failed to uncover the specific preconception, the teacher needs to organise a lesson to help children correct their preconceptions. Finally, as teacher 5 stated “I think that you can convince children for the correct concepts when you know what they believe. If you do not know or ignore their concepts and preconceptions, it will be more difficult for you and for the children, as well.”

Preconceptions and their disadvantages for the children’s learning was another issue that was discussed during the focus groups and the interviews. Teachers 6, 7 and 8 believe that it is ok for children to leave the classroom or even pre-primary school and still have some preconceptions. Teacher 8 particularly stated that “When children grow up, they will understand and learn what is correct. It depends on how mature they are. It is not the main aim of the pre-primary school to change these concepts because they will do them again at primary school, high school etc."

Teacher 8, who teaches three- to six-year-olds, came to agree with this and said "Yes, of course. And, if you realise that those children are usually faster and understand what you want to teach easily, if they have not understood it, then something went wrong. But, if it is a child that always has difficulties with understanding what you teach, then it is ok. It may not be ready yet; they may still not be mature enough to accept what you teach. Teacher 7 added that the aim at pre-primary school is not to teach children science but to help children develop their skills (e.g. observation, prediction). According to the same teacher "If there are children with preconceptions, if they have developed the skills that we aim at this stage, then they can use these skills in the future to learn and eliminate those preconceptions by themselves because they will learn how to learn, how to discover." Teacher 6 believed that "It is better to move to another topic that might be more interesting for children than teaching the same topic for a long time and insisting on the same concepts which are difficult for some children." To explain herself, she gave an example of children who are scared of some natural phenomena (like thunders and lightning). As she said "We will work in the class to explain that there is no reason to be scared of these phenomena. If some children still feel fear, then we can ask parents to talk about it, as well, when they are at home, but we cannot talk about the same thing all the time."

Similarly, teachers 2, 4 and 5 expressed the opinion that preconceptions do not affect the children's learning. Teacher 2 stated that "Children pass through phases on their own and they change what they believe through time. Only if something is really intense in their minds, it will be hard to change. I could say that their preconceptions are cute and they usually accept what their teacher says during the lesson, even if they believed something else so far. But, some of them will not change what they think." Teacher 4 also believes that preconceptions do not affect the children's learning and as she said "Children accept what we tell them very easily because we are their teacher and they believe us."

The teachers that participated in the focus groups and the interviews expressed the opinion that children do not arrive at pre-primary schools as tabula rasa. Specifically, teacher 1 said: "I think that children know a lot of things when they arrive at school but they may not realise it, they have not organised their knowledge. For example, every morning when they drink their milk and put sugar in it, they know that sugar dissolves, or that when the radio is not plugged, it does not work, but they might not know how to say it or explain it. They know that rain comes from clouds but they may not know how. They also know that without light, they cannot see and that when they want to talk to someone who is far from them, they have to talk louder. They know a lot of things and when they come to school, we need to organise the concepts that they have."

Teachers 2 and 3 both agreed that children are not tabula rasa and stated respectively: "I agree with both suggestions but, for example, I would not say that at the age of 4 a child does not have any experience, so it is not tabula rasa, but a younger child may have less. And, it is more correct to acknowledge what they know, even if it is a very tiny thing." And "Children know some things when they arrive at the pre-primary school. I disagree completely with the opinion of 'tabula rasa.' As teachers, we need to know this prior knowledge, because if you do something that children do not have experience about, they will not understand you and they will not be interested. So, you will need to give them experiences."

However, teachers 1, 3, 9, 10 and 11 expressed the belief that preconceptions can be an obstacle for the children's learning. In particular, teacher 3 said "I think that preconceptions can have a negative impact on children; they will get confused and will mix up the preconceptions with the correct. On the other hand, if what they know is correct, they will build on it." Teacher 1 gave a simple example of why being aware of the children's preconceptions can be helpful from her point of view. She said: "Let's say that I want to teach magnets. If my students know what magnets attract, I will not waste a whole lesson talking about that. I will cover that quickly and go on to the next thing about magnets. But, if I have a class that does not know anything about magnets, I will do it differently." Teachers 9, 10 and 11 were the only ones that specifically said that teachers should not ignore the children's preconceptions before or during a Natural Sciences lesson and teacher 9 supported that it is better to cover fewer subjects in more depth rather than quickly go through a lot of subjects without giving time to children to express their concepts and correct their preconceptions. As he said "It is better to just cover five topics and do them well and make sure that the children have learnt what you want them to learn, rather than cover fifteen topics very briefly."

The teachers' response to the children's preconceptions and how they handle them during a Natural Sciences lesson was another important issue that was discussed. Teacher 1 confessed that, at the beginning of her teaching career, she did not do anything specific to handle the children's preconceptions. As she explained "I just taught my lesson in the way that I had it planned, based on what I had learnt during my studies. I ignored preconceptions. I thought that they were not affecting my lesson." And, she continued "A few years later, I started realising that children arrive at schools with their own experiences. Now, I usually use the children's preconceptions to begin a lesson." This teacher pointed out that there is no such thing as "a recipe" that can be used to eliminate the children's preconceptions. As she said "Teachers need to start from the beginning every time, because every year we have different children, with different ages, coming from different areas, with different experiences. All these things need to be taken into consideration before planning and organising a lesson."

Teacher 3 also agrees with the opinion that there is no correct "recipe" when it comes to the children's preconceptions and as she explained "It depends on the specific preconception, on the teacher's instinct and on how the teacher thinks that it is better to handle it. I believe that there are a lot of ways to help children overcome their preconceptions. It depends on the specific children and the teacher." She added that teachers need to accept all the preconceptions expressed by children inside and outside the classroom. "Teachers need to talk to their students outside the classroom, as well, because that is when the child will talk to you without fear and you will get to know what concepts the child has. I try to give the children the opportunity to talk and say express their ideas and accept them without criticism. All ideas are respected and we should never make them feel uncomfortable to say what they believe."

On the other hand, even with a teaching career of 25 years, teacher 2 reports that she does not do anything to respond to the children's preconceptions.

As she reported “I do not do anything specific. If something comes up during the lesson, I find a way to use it. For example, when I was teaching Magnets, a boy said that magnets attract wood. That was during the discussion when everybody had a material in their hands and had to say if the magnet would attract it or not. After that, we had the investigation during which everybody tried their material with the magnet, so the boy saw that wood was not attracted. So, there was nothing more for me to do.”

Teacher 4 supported the opinion that the best way to respond to the children’s preconceptions is to offer the children the necessary experiences aiming to correct their preconceptions. As she described: “When children try things experientially, they realise that they are wrong. For example, if they think that stones sink, when they try it out, they will see and believe that they do not sink. The most appropriate is to use experiments. She also highlighted the importance of having teachers that are free of alternative concepts themselves. As she elucidated “First of all, teachers, including myself, need to overcome their own alternative concepts, be informed and have sufficient subject knowledge about what they want to teach in order to be able to help children overcome any preconceptions they might have. It is important to always begin with an activity that will help to identify the children’s preconceptions and, then, the most appropriate way to eliminate them is with the use of experiments because, when children experience something, they can understand it better.”

Teacher 5 added that the environment in the classroom is also important and she believes that “The most appropriate is to create an environment where children will explore and discover the correct concepts and what you want them to learn on their own. You need to organise the activities in a way that children will discover and you will not ‘give’ them ready knowledge. If you just talk to them, they will not believe you. Even if they listen to you and they repeat what you say, they will just do it to make you happy and not because they will believe you are right. Children need energetic learning in order to understand and learn.”

This opinion was also expressed by teacher 7, who came to add that after a number of experimental activities, some children will be able to correct their preconceptions whereas some others will not. She explained that, this usually happens with those preconceptions that are held by children for a long time and have become resistant to change and, thus are more difficult to correct. She actually said that “Some children have had some preconceptions for such a long time that they have become so powerful and, therefore, they will not change easily. Children will strongly believe that their concepts are correct.” The same teacher confessed that she had never thought that she could have done something to help children correct their preconceptions. She specifically said “The truth is that, even though I have heard children expressing preconceptions during a lesson numerous times, I never thought of how I could eliminate these preconceptions, before now. I feel that after our discussion, I can identify these preconceptions that children have and pay more attention to them and to how to work with children to help them.”

Teacher 6, who participated in the same focus group with the above teacher, came to agree with her colleague, but also asked the following question: “Can a teacher help those children that are not mature or clever enough?” Answering her own question, she said: “Because of the lack of time and other difficulties that teachers face, we cannot help this kind of children. We can identify which children have problems, but we have trouble dealing with these specific children individually because we do not have enough time."

All three teachers that participated in the second focus group (teachers 9, 10 and 11) agreed that it is important for teachers to help the children understand on their own which of their concepts are not correct and why. Teacher 9 explained that to accomplish this, he gives the children opportunities to try things. He said that: "This is the best way for children to realise that what they believed so far was not true and, thus correct their preconception without needing me to explain or say that what they believe is wrong." Teacher 11 added that it is also important to give each child the opportunity to participate during the experiments and also try all the different concepts expressed by the children. She further explained that "Trying everything that they say is the only way to convince them. And then, the results of the experiments should be written and kept on the "Natural Sciences' corner" table to give the opportunity to children to go back to them. I often watch the children going there and looking at the results again and, when we have visitors in the class, children will take them there to show and explain what we have done." Her conclusion was that it is important to always do something to respond to the children's preconceptions because only then will children learn something that will be part of their knowledge for the rest of their lives. As she said "The aim of the pre-primary school is to teach children something that will help them in their lives and make them able to use their knowledge in different settings. To do this, we need to offer them a lot of experiences."

At this point, it is important to note that from all the teachers who participated in the interviews and the focus groups, only teacher 9 (with 2 years of experience) said that he had some training on the children's preconceptions during his studies. The answers given by the rest of the teachers prove that none of them had received specific training on the children's preconceptions during their studies. Teachers with more than two and fewer than ten years of experience said that they did have a specific module for Natural Sciences but that they did not do any training specifically on the children's preconceptions. For example, teacher 4 said that: "The training that I had on Natural Sciences during my studies was very limited. We neither learnt how to teach Natural Sciences nor talked about the children's preconceptions during our studies. The first year that a teacher works at a school, she is not be able to teach successfully. She will have to learn how to teach through experience."

In addition, teacher 10 (with 9 years of experience) said "I do not remember covering anything on the children's preconceptions during my studies. We did talk about the children's prior knowledge and their importance and also the importance of having a diagnostic activity like 'prediction', but we did not talk about the children's preconceptions." Teachers with fewer than 10 years of experience reported that, even if they did have specific module on Natural Sciences, they still did not feel that they were ready to teach the specific lesson by the end of their studies. As they said, most of what they know today comes from the experience that they gained throughout the years.

On the other hand, teachers that completed their studies ten years ago or more did not have a specific module for Natural Sciences during their studies.

Thus, everything that they know is due to their working experience. Specifically, teacher 11 (with 16 years of experience) said that “I do not even remember having a module on Natural Sciences’. We only did some things about ‘Ecology’ as it used to be called then. We did something on instructive methodology, but not specifically for Natural Sciences; it was more general. They tried to provide us with knowledge about phenomena like the greenhouse phenomenon and not knowledge on how to teach Natural Sciences. Our studies aimed to give us scientific knowledge and teach us how to learn.” In addition, teacher 3 (with 25 years of experience) added that “The reference book does not say anything about the children’s preconceptions either, which makes our work even more difficult.”

Teacher 5’s response came to support the above statement since she also said that she did not receive any training about Natural Sciences either during her studies. She said that: “When I went to study, it was the second year of the Pedagogic Academy and things were still at their beginning. We learnt a lot about ‘Free Activities’ and ‘Language - Literacy’, but the subject of Natural Sciences was not covered at all. I have to say that the training that we received during our studies was very poor in regard to Natural Sciences. And apart from that, I also think that for a long time, the knowledge that we had about Natural Sciences was wrong.”

In general, the teachers’ responses indicate that teachers are not satisfied with their training and knowledge in regard to this specific topic. When the teachers were asked to report what would make them feel more satisfied, they suggested that more seminars and conferences need to be organised for Natural Sciences. Teacher 5 said that “Teachers need better training before they start working and during their teaching years. We need people to come and teach us how to teach; people who will show us and not just talk to us. All of us need to observe lessons and see what mistakes we usually do and how we can correct them. I attend online classes in the U.K. where they work in groups for the whole lesson. They do not have this traditional way of having children in a circle and the teacher talking and talking all the time… and I wonder why I cannot do that? Why hasn't anybody taught me how to do that? And, when you first start working, you are so excited and are so revolutionary and you want to change things but, then, when you see that nothing of what you do is recognisable, you do everything by yourself and you spend time and money, then you start wondering why you should even bother?" Teachers also said that the teacher's training needs to have something more specific on the children's preconceptions and as teacher 11 added "Children do not have preconceptions only for Natural Sciences but for all the topics that are taught. A module preparing teachers for these preconceptions would be very helpful."

Before the end of the interviews, the teachers were asked to explain how they would call preconceptions if they were asked to give them a different label. In a similar way, right before the end of the focus groups, teachers were asked to give their own definition about what 'preconceptions' are. In general, all teachers, even if most of them did not have any specific training on the children's preconceptions, they were able to talk about preconceptions and give their own label or definition for them. The following table presents the answers given by each teacher or focus group based on their experiences and the discussion that we had. Each focus group gave one definition which was discussed and accepted by all the participating teachers.

Tables and Figures 20: Teachers' Labelling/ Definition for 'Preconceptions'

Teacher/ Focus Group	**How teachers would call 'Preconceptions'/ Their own definition**
Teacher 1	I would call them 'Experiences' because it is what children experience and the teacher is responsible to correct them, if necessary. They are concepts some of which may be correct and some may be wrong. I could also call them 'Initial concepts' because they will change in the future but I think that 'Experience' is more correct. They come from their house, the things that they do when they are home. From their family and their experiences.
Teacher 2	I would call them 'Concepts' that they have based on their experiences. I think that they come from their family, like older brothers, parents etc.
Teacher 3	I would call them 'Impressions". 'Impression' is something that children believe and it may be fully correct or a part of it may be correct or it may be completely wrong. All the experiences the children have had in their lives, have taught them something, they have made them think and have created 'impressions' in their minds.
Teacher 4	I would say 'Pre-school experiences' for those experiences that children have before entering schools and 'Meta-school experiences' for those experiences that children will conquer during school. This will include the correct and the wrong concepts concluded from these experiences.

Teacher 5	I would say that they are 'Experiences' they gained ever since they were born or even before that. I would call them 'Initial experiences'.
Focus Group 1	Preconceptions are the children's explanations about a scientific phenomenon which usually emanates from their imagination. Since children do not have enough knowledge about know how to explain a phenomenon, their explanation is wrong. And it depends on their experiences, as well.
Focus Group 2	Preconceptions are the children's own concepts about a phenomenon that do not agree with what is generally accepted in science but they are logical for children.

As indicated in the above table, and based on the teachers' responses, all teachers agree that preconceptions are the children's concepts, which originate from the children's experiences. Teachers chose to give a label to preconceptions that would indicate that there is a connection between these concepts and the experiences that children have. Teacher 8 added that the fairy tales that teachers use can sometimes have a negative impact on the children's knowledge and reinforce preconceptions because, as she said: "The information and the vocabulary given in a fairy tale are not always scientific and this can be confusing for children."

Based on the literature review, it is important to recognise the fact that when talking about, and especially when defining, the children's preconceptions, it is inappropriate to suggest that preconceptions refer to the children's concepts which are correct. However, only the two focus groups (teachers 6, 7, 8 and 9, 10,

11) pointed out that preconceptions are not just any concepts that children have, but that they are concepts which do not agree with what is generally accepted by the scientific community. On the contrary, teachers 1, 4 and 5 suggested that preconceptions are concepts which might be correct or wrong. Such a statement would not be accepted by experts on the subject."

Additionally, teacher 4 talked about issues that make a teachers' job more difficult and, as a result, some children end up leaving pre-primary school and still have preconceptions (meta-experiences according to teacher 4). As she explained, "Because of the big number of children in each class, the teacher does not have the ability to check and correct every single preconception that children have. This is something that always happens. We also have children with special needs in the classroom, which makes it even harder, in addition to the lack of equipment, the lack of materials and lack of time."

Teacher 5 also referred to the difficulties described by teacher 4 and added that "Twenty-five children with different abilities, experiences, needs and maturity is not a small number and the fact that there is only one teacher assistant for two teachers to share, makes it even more difficult." She also talked about constructivism and referred to Piaget and Vygotsky. Specifically, when she was asked to define preconceptions she said: "Piaget talked about constructivism. Children build their knowledge through their experiences. Therefore, teachers need to know the children's preconceptions in order to work with them within their Zone of Proximal Development, a term firstly used by Vygotsky and which means that they will reach their maximum ability to learn. Of course, this is not always possible or feasible since the number of children in the classroom does not help."

7. 2. 1. c. 3. Teachers' Topic Preferences

Teachers were also asked to give information about their topic preferences, meaning what topics they teach more often, what topics they feel confident to teach and what topics they avoid teaching. Their responses are presented in the next table.

Tables & Figures 21: The topics that teachers feel confident to teach/ teach more often/ avoid teaching.

Confident to teach	**Teach more often**	**Avoid teaching**
Weather-Water Cycle (4 teachers)	Weather-Water Cycle (4 teachers)	Electricity (5 teachers)
Plants & Animals (2 teachers)	Plants & Animals (2 teachers)	Light & Shadows (3 teachers)
Human Body (2 teachers)	Human Body (2 teachers)	Sound (2 teachers)
Materials (2 teachers)	Materials (2 teacher)	Heat- Energy (1 teacher)
Magnets (1 teacher)	Magnets (1 teachers)	

As indicated in the above table, the most popular topic is 'Weather-Earth-Space' and specifically 'Water Cycle', since four teachers say that they feel confident to teach it and they choose to teach it more often. The next three popular topics with two teachers stating that they feel more confident to teach them and which they choose to teach more often in comparison with other topics are ‘Plants & Animals’, ‘Human Body’ and ‘Materials’. Finally, one teacher said that she feels confident to teach ‘Magnets’ and that she chooses to teach this subject more often than others. It is also important to notice that the topic that each teacher feels more confident to teach is exactly the same with the subjects that he/she actually chooses to teach more often.

On the contrary, ‘Electricity’ seems to be a topic that most teachers would avoid teaching as five of them said that they would prefer not to teach this topic. Three teachers said that they would avoid teaching ‘Light and Shadows’, two of them would avoid ‘Sound’ and one of them said that she would prefer not to teach ‘Heat and Energy’.

When the teachers were asked to explain why they would avoid these topics, teachers 1 and 4 said that they do not like teaching ‘Electricity’ because they do not have the necessary materials to teach it. Similarly, teacher 5 would avoid teaching ‘Electricity’ and ‘Light’ because, as she said, “I feel that I do not know them well, I have never tried to teach them. Maybe because I did not study science at high school, I feel that I do not have sufficient knowledge for these topics.” Teacher 2 stated that “I have never taught ‘Electricity’ so far because I do not feel confident and, since we are free to choose what to teach, I avoid it. But, I would like to try it someday and, if I had somebody to guide me and advice me, I would teach it.” Finally, teachers 3 and 4 both said that they are afraid of teaching some specific topics. Specifically, teacher 3 said that “I would avoid ‘Light and

Shadows' because I do not usually have enough time to teach it and I am a bit scared because I am not familiar with these topics." In the same way, teacher 4 stated that "I have never taught 'Sound' because I am a bit scared to try it." Teacher 5, who is also the school headteacher, confessed that she has talked with teachers who feel fear or do not feel confident to teach some specific topics.

On the other hand, when teachers were asked to explain why they would choose to teach some specific topics more often than other topics, their responses varied. Some of them said that they would do it because they feel more confident and because they have better subject knowledge. For example, teacher 9 said that "If a teacher likes a topic and also has the skills and the necessary knowledge, she will try to take children even further and insist on the specific topic." Teacher 5 agreed with this, since she reported that "I prefer to teach topics that I know well because I feel more confident. I think I can take some other topics into more depth as well but I do not do it because when I teach something, I want to be sure about my knowledge on that. In order to do that, I would have to spend more time investigating and learning things about science."

Some other teachers, however, said that they would choose to teach specific topics/subjects because children like them more. For example, teacher 1 said that she would like to teach certain topics "Because children can do a lot of things, they can be active and engage and it is not just me talking and them repeating. I do not like it when I am talking and children are just listening. I prefer to have a lesson during which the children can work in groups and try things on their own when it is safe." Similarly, teacher 2 explained that she chooses to teach 'Plants and Animals' "Because children like it." Teacher 3 said that she prefers one topic instead of another “Because you can do a lot of things that children can see and this topic is more understandable by children.” Finally, teacher 4 had the same opinion and said that she chooses teaching ‘Water Cycle’ “Because children like this topic a lot and they get excited.”

7. 2. 1. c. 4. Time Dedicated to Natural Sciences

The last tree node to be presented here is ‘Time Dedicated to Natural Sciences’ which includes information about how teachers manage their teaching time in regard to Natural Sciences. The first thing to notice is that teachers talked about ‘lack of time’. Teachers support that the time that they have is not enough for all the things they have to do. As a result, the lack of time might prevent teachers from identifying the children’s preconceptions. For example, teacher 4 stated that “We (teachers) assume a common base of knowledge which is a mistake, but we do it because it is convenient and easier, we do not have enough time to do everything from the beginning and this is the truth.”

Teachers also talked about how much time they devote to prepare a Natural Sciences lesson. Teacher 9, for example, said that “Even if I had not studied science at high school, Natural Sciences is still one of the subjects that I enjoy teaching, despite the fact that it needs more preparation than other lessons.” Teachers 10 and 11 agreed with him and both admitted that natural science is a time-consuming subject to teach because it needs a lot of preparation.

Teacher 1 agreed with the above statements as well. As she explained, it usually takes her more time to prepare a lesson for this specific subject because “It takes me more time to think good activities and make sure that I will be teaching

Natural Sciences indeed and that the lesson will be successful. It takes me longer to think about the activities that will help children to achieve the goals of the lesson and organise the lesson. On my first year, I also spent long hours preparing material and pictures because I used to have a picture of a glass and a real glass as well. Now, whenever I can use the real thing, I do not use pictures anymore. Thus, it takes me less time to prepare but I never go without any preparation."

Teacher 2, on the other hand, said that she does not need more time to prepare for this specific subject and as she stated "It takes me more or less the same time like other subjects. The first time you try to teach something, takes longer to prepare and organise everything and find what you need. But, the second time is easier and so on." In addition to this, teacher 5 reported that "I think that it takes equal time to organise and teach it as well, just like any other subject. You may need more time than what you need to organise other subjects, like literacy or music."

Teacher 3, however, did not agree with teacher 2, since she stated that "It needs a lot of preparation and thinking and good management skills. You need to prepare a lot of things to do the lesson, like different materials for each team, and it is more difficult to manage the class when you teach Natural Sciences in comparison to other subjects. It takes longer to organise Natural Sciences than to organise other lessons." Teacher 4 agreed and added that "You need a lot of time to organise a Natural Sciences lesson and find the materials that you are going to use for you experiments and for the prediction and verification activities. This usually takes some time to do, a bit more time than you need for other lessons."

Another issue about time that was discussed during the interviews is how many periods per week teachers teach Natural Sciences. According to the teachers, one teaching period might last from thirty to forty minutes and the curriculum does not specify how many periods per week each subject should be taught, but it highlights that all subjects need to be taught at least one period per week. Teacher 2 specifically said that "The curriculum does not mention a specific number of hours but it says that all subjects should be taught. But, if you do more of a specific subject in one week, you can do less next week. It is not like primary schools where you have to teach specific subjects and specific hours every week." Teacher 7 agreed and said that "We sometimes teach Natural Sciences for two periods every week, or we can do one period this week and two periods the next one. It depends on the specific topic that we want to teach."

On the other hand, teacher 1 reported that, based on her experience, at the beginning of the school year, a plan is made by the teachers about how many hours per week each subject should be taught. As she said, Natural Sciences are usually expected to be taught twice a week. However, she explained that this programme is not always strictly followed because "We begin the year saying that Natural Sciences has to be taught twice a week but it is hard to do this... because sometimes the headteacher teaches the lesson instead of me and if I am not present in the classroom on that day, I do not know for sure if she has actually taught Natural Sciences and how she has taught it. Yet, I try to do almost one period per week. But, for example, when we have rehearsals for the school's final celebrations, we waste a lot of time on that and this time is mostly taken from Natural Sciences because children are already tired and they cannot do Natural

Sciences as well because it is a difficult subject. My personal opinion is that we should not do all these school celebrations because we waste a lot of time. So, you can mention this in your thesis and hopefully somebody will take it into consideration."

Teacher 4 also made a reference to the school's headteacher and said that "Teachers may not be restricted by the curriculum but they may receive pressure by their headteachers and by themselves because there are a lot of things that you can do in Natural Sciences and it is not fair for children to do only some of them. It is usually taught two periods per week but there are times that you will do one period or none, depending on how many other things you have to do. Of course, it also depends on the topic and the fact that it may not be completed in only one lesson. For example, 'Water Cycle' can take from four to six lessons."

Teacher 5 added that the periods of time that a teacher will devote to Natural Sciences also depend on the school's location (city or village) and also the children in the class. As she said "It is usually between one to two periods per week, even if it could be done more often. We could use this subject to teach other things, as well. You can do everything through Natural Sciences. This freedom that we have can damage Natural Sciences because some teachers choose not to do it at all, even if the curriculum says that all subjects must be taught. I think that the curriculum should be more structured and should not give so much freedom to the teachers." This issue will be further discussed in the next chapter.

The results deriving from the interviews and the focus groups are listed at the end of this chapter. They are also further discussed in the next chapter, along with the results deriving from other research methods, in order to answer the research questions.

7. 2. 2. Observations' Analysis and Results

The last results to be presented are the ones collected through the observations. A total of six lessons were observed and each one of them lasted approximately thirty-five minutes. Teachers 1, 2, 3, 6 and 11 that participated in the interviews/focus groups were also observed during the lessons 1, 2, 3, 4 and 5, respectively. Although she did not participate in the interviews or the focus group, teacher 12 was added to this group and was observed during lesson 6.

The next table presents general information about each teacher who participated in the observations. Before the beginning of each observation, each teacher was asked to read and complete an information sheet. The teachers were asked to give information about the length of their teaching experience, the number of children in their classroom during the specific year and their background and attitudes about teaching Natural Sciences. In addition, information was also collected about the classroom environment and the existence or not of a Natural Sciences corner. Finally, the table makes a comparison between what the teachers said about identifying preconceptions and what they actually did during the observation.

Tables & Figures 22: Information on teachers' portrait

Pseudonym	Teacher 1 Lesson 1	Teacher 2 Lesson 2	Teacher 3 Lesson 3	Teacher 6 Lesson 4	Teacher 11 Lesson 5	Teacher 12 Lesson 6
Years of teaching experience	9	25	25	31	16	8
Number of children	19	20	25	18	17	21
Science at high school	Yes	No	No	No	Yes	No
Natural Sciences' seminars	Yes	Yes	Yes	Yes	Yes	Yes
Like teaching Natural Sciences	Agree	Agree	Agree (but its' boring)	Not sure	Strongly Agree	Strongly Agree
Confidence teaching Natural Sciences	Not sure	Agree	Not sure	Not sure	Agree	Agree
Natural Sciences	Yes	Yes	Yes	Yes	Yes	Yes

Corner						
Lesson Plan	Yes	Yes	Yes	Yes	Yes	Yes
Any preconceptions during lesson	Yes	Yes	Yes	Yes	Yes	Yes
Identify preconceptions (during lesson)	No	No	No	No	Yes	No
Identify preconceptions (at interview)	Yes	No	Yes	Yes	Yes	Yes

Based on the above table, the teachers that were observed had a mean of 19 years of teaching experience and a mean of 20 children in their classrooms. Only two out of the six teachers studied Natural Sciences at high school and these were teachers 1 and 11. All of them have attended at least one seminar for Natural Sciences but nothing specific for the children's preconceptions. All of them agreed or strongly agreed that they like teaching Natural Sciences, except for teacher 6, who was not sure. However, only teachers 2, 11 and 12 agreed that they feel confident when teaching Natural Sciences, whereas teachers 1, 3 and 6 said that they were not sure about this.

In addition, there was a table in all the classrooms labelled as 'Natural Sciences' corner' but only in teachers 1 and 11 was the topic of the Natural Sciences' corner the same with the topic being taught in that specific week. In the rest of the classrooms, the topics that the ‘Natural Sciences’ corners’ presented were covered in previous weeks. All classrooms were similarly arranged and children were sitting in a circle listening to the teacher. The rooms did not reflect the subject being taught since the same room is used for all subjects.

All teachers provided a lesson plan with the learning objectives and the activities, apart from teacher 1 who only wrote the learning objectives of the lesson. For all lessons, the learning objectives were easily identified and there was a match between the planning and the reality of the lesson. However, none of the teachers included the children’s preconceptions in their lesson plan but during all the observed lessons a number of preconceptions were expressed by the children. There was no sign of how the children’s preconceptions would be used or of any evaluative activities in the lesson plans.

During most lessons, the transition between activities was smooth, besides lesson 4 and 6, as the teacher tried to fit a lot of activities in a short period of time. This gave a feeling that the teachers were in a hurry to cover everything and children were struggling to follow the frequent transitions between the activities. There was not any group work observed. Only teachers 1 and 11 included an experiment in their lessons. In all cases, there was a brief review at the end of the lesson, even if in most cases the review was made by the teacher and only two or three children. Finally, even though the teachers[9] reported that it was important to identify the children’s preconceptions when teaching Natural Sciences, only one of them (teacher 11) actually did so during the observations.

[9] This question was asked during the interviews and the focus groups. Teacher 12 answered this question verbally during the completion of the information sheet before the beginning of the lesson.

Finally, only teacher 11 shared the aim of the lesson with children. All teachers tried to give clear instructions and feedback to children and had a summarising activity at the end of the lesson (even if the appropriateness of some activities can be questioned). The teachers used different styles of teaching: teacher 3 used problem solving, teacher 6 used demonstration, teachers 1 and 11 used experiments, and all of them used discussion and explanation. However, only teachers 1 and 11 used challenging and open-ended questions, whereas most questions asked by the rest of the teachers were closed ones.

The previous table focused on the teachers, whereas the next table focused on the lessons. The main aim of the observations was to identify how much lesson time was focused on the children's preconceptions and in what way. This is what the next two tables aim to demonstrate in addition to a summary and some general information for each lesson in an attempt to give an idea about the activities included in each lesson.

Tables & Figures 23: The main methods used during each lesson and a quick summary of each lesson and the activities.

	Main Methods Used	**Description of lesson**
Lesson 1 Teacher 1	Experiment- Discussion - Pictures	Picture: river - discussion: use of water. Picture water cycle experiment: boiling water – steam - cold plate – water drops- discussion
Lesson 2 Teacher 2	Story Telling - Role Play - Pictures	Rain last night (sound of raining), Song: 'Rain', Fairy tale about the trip of a rain drop, role play representation of story
Lesson 3 Teacher 3	Problem Solving - Story Telling - List of	Puppet – a frog lost its lake, Where has it gone? Song: 'Cloud', Tea for guest - steam from kettle - Where else do we see steam? - List of ideas,

	ideas	examples, fairy tale: the water drops that wanted to travel
Lesson 4 Teacher 6	Story Telling - Role Play - Art	Fairy tale – a water drop is going on a trip and her mum said that she will become steam - what is steam? Give examples Continue story - summarise - role play represent story - Draw picture based on story
Lesson 5 Teacher 11	Experiment - Discussion - List of ideas	“Now we are scientists”, Fairy tale from morning, connection: where do clouds find rain? List of ideas, Experiment: boiling water - steam-cold plate – water drops, water = sea, fire = sun.
Lesson 6 Teacher 12	Story Telling - Pictures - Art	Fairy tale “The feathered cloud” Put pictures in a circle for storytelling, circle = ‘Water Cycle’, Summarise - Repeat Story - This happens all the time, Discuss colour of clouds, Draw a picture based on story - ‘Water Cycle’

As it has already been said, during the observations, notes were taken in regard to the teachers’ actions in general and also with specific focus on those actions that gave information about the teachers’ responses to the children’s preconceptions. Thus, in addition to the above table, the following table provides specific information about how each teacher worked on the children’s preconceptions during the lesson. The presentation of the table is divided in minutes, based on the observation schedule that was used during the observations.

Tables & Figures 24: Information for each lesson with focus on the children's preconceptions.

Time in minutes	Lesson 1 Teacher 1	Lesson 2 Teacher 2	Lesson 3 Teacher 3	Lesson 4 Teacher 6	Lesson 5 Teacher 11	Lesson 6 Teacher 12
0-5	Ignore preconceptions	/	/	/	Identify preconceptions	/
5-10	Ignore preconceptions	Ignore preconceptions	Ignore preconceptions	Ignore preconceptions	Work on preconceptions - class level	/
10-15	/	/	Ignore preconceptions	Ignore preconceptions	Work on preconceptions. - class level	Ignore preconceptions
15-20	/	/	/	/	Work on preconceptions - class level	Ignore preconceptions
20-25	/	/	Ignore preconceptions	/	Work on preconceptions -	/

					class level	
25-30	Ignore preconceptions	Ignore preconceptions	/	/	Work on preconceptions - class level	/
30-35	Work on preconceptions - class level	/	Ignore preconceptions	/	/	/

Preconceptions were expressed throughout the lessons and were recognised by all teachers. However, only in two out of the six lessons the teacher chose not to ignore them. These two teachers, 1 and 11, chose to work on the children's preconceptions. As shown in the above table, only five minutes out of lesson 1 and twenty-five minutes from lesson 5 focused on working on the children's preconceptions, whereas no time was given during the rest of the lessons to work on the children's preconceptions.

Specifically, teacher 1 preferred to identify the preconceptions that the children were expressing during the lesson and complete her planned lesson, which included an experiment. At the end of the lesson, she asked specific questions to identify if the children still had the preconceptions that they expressed before the experiment. Then, she focused on the remaining preconceptions and she tried to help those children with the specific preconceptions to overcome them. To accomplish this, she invited the class to a discussion based on the experiments to explain why the specific concepts were incorrect.

On the other hand, teacher 11 identified the children's preconceptions during the first five minutes of the lesson. The experiment was the main activity that helped the teacher to focus on the children's preconceptions and also helped the children to understand the phenomenon better. This enabled her to teach the concepts that she had planned, by inviting the children to express their concepts, by making a list of ideas, and at the same time working on the children's preconceptions throughout the lesson. In both cases, the teachers worked on the children's preconceptions on a group level. In the other cases, the teachers ignored the preconceptions expressed by the children and followed their lesson plan.

As it has already been said, children expressed a number of preconceptions during the observations. This gave the opportunity to create the list below, which includes all the preconceptions that children expressed.

- Teacher 1 - Lesson 1
    - God cries and it rains
    - Clouds are made of cotton
    - Water is white
- Teacher 2 - Lesson 2
    - Rain comes from God
    - Rain drops are God's teardrops
    - Water can disappear
    - Water disappears faster when you heat it
    - Hot water becomes smoke (vocabulary)

- Teacher 3 - Lesson 3
    - Water can disappear
    - Hot water becomes smoke (vocabulary)
    - Clouds are made of cotton
    - Clouds are made of smoke
    - Water is white
    - God makes clouds
    - Judas/ Anger/ Jesus turns water into clouds
- Teacher 6 - Lesson 4
    - Birds and fish help sea water to become cloud
    - Clouds are made from steam that comes from the kettles (and the water that we boil in our houses in general e.g. for cooking)
    - Clouds can be any colour l(based on the children's drawings)
- Teacher 11 - Lesson 5
    - Clouds can follow us
    - God/ Jesus makes clouds
    - Sky makes clouds
    - Clouds are made of steam that comes from the kettles (and the water that we boil in our houses in general e.g. for cooking)
- Lesson 6- Teacher 12
    - Clouds are made of feathers
    - Clouds cry and we have rain
    - Rain drops are alive and they can choose where to go
    - Hot water becomes smoke (vocabulary)

The above list can assist to make a comparison with the examples of the children's preconceptions that the teachers gave during the interviews and the focus groups and will be part of the next chapter. Similarities and differences which can help to discuss the children's preconceptions and answer the research questions will be identified through such a comparison.

7. 2. 3. Document Analysis and Results

As it has already been said, document analysis was used as a supplementary method in this multi-method case study. The main focus of the document analysis was to examine if the document - reference book entitled 'Natural Science in the Kindergarten - a guide for the early-years' teacher' (original title in Greek: Οι Φυσικές Επιστήμες στο Νηπιαγωγείο- Βοήθημα για τη νηπιαγωγό) mainly used by early-years' teachers acknowledges the children's preconceptions. As a result, the use of document analysis also helped to examine how the reference book can affect the teacher's Natural Sciences teaching.

This reference book was published in 2004 and the names of the authors that appear in the first page of the book are: Christoula Nicolaou (Χριστούλα Νικολάου) and Eleftheria Kiriakidou (Ελευθερία Κυριακίδου) with guidance from: Georgia Feronimou (Γεωργία Φερωνύμου) and Dr. Konstantinos P. Konstantinou (Δρ. Κωνσταντίνος Π. Κωνσταντίνου). As they highlight at the beginning of the book, planning and organising a Natural Sciences lesson has always been a more complex and demanding procedure in comparison to other subjects. They explain that this is due to the fact that Natural Sciences is a demanding subject since it involves many different concepts and skills and requires teachers to be multi-tasking and find ways to combine different topics to teach science (Nicolaou & Kiriakidou, 2004).

As explained by the authors in the introduction of the book, the reference book aims to a) support the children's construction of knowledge by emphasising on experimenting and active engagement, b) respond to kindergartens' needs and abilities, c) be planned and give support based on the Natural Sciences' priorities and structure and, finally, d) provide long-term support for lesson development and encourage constant questioning for further improvement and adjustment by each early-years' teacher (Nicolaou & Kiriakidou, 2004). In addition, the reference book is based on that: a) Natural Sciences support the children's knowledge development and b) Natural Sciences demand skills which do not exceed most children's abilities (ibid, 2004).

The reference book consists of two parts. The first part gives information and explanations about the learning objectives and the skills that children need to develop through Natural Sciences. Emphasis is given on the children's thinking skills and on experimenting. In this part, teachers can find guidance and information necessary to develop their short- and long-term planning. The second part provides lesson examples which have been tried in actual classrooms. However, the results indicate that teachers usually copy these lesson examples instead of using them as guidance to plan their own different lesson according to the children that they have in front of them.

The authors highlighted that early-years' teachers need to plan lessons that will respond to their own interests, but will take into account the children's interests, as well. In addition, the authors stated that if the children are able to give their own explanations and definitions at the end of a series of lessons, it means that they have had the appropriate guidance and the lessons were successful. They also support that group work is very helpful when teaching Natural Sciences and the teacher needs to move around the classroom and work as the coordinator who will guide the children through the procedure of investigation.

The analysis of the reference book revealed that there is no reference made about the children's preconceptions. This suggests that the authors of the book did not identify as important to inform the teachers about how preconceptions can affect the children's learning and how teachers can help the children overcome their preconceptions through their teaching or, at least, explain what preconceptions are. In addition, the reference book suggests that Natural Sciences are not only about learning scientific concepts; this might make teachers believe that they are not responsible to help the children overcome their preconceptions. However, according to the authors, when reading the instructions on how lessons should be developed, we can see that the children's prior knowledge needs to be taken into account when planning a lesson.

The results of the document analysis revealed that the reference book used by the overwhelming majority of teachers does not refer to the children's preconceptions and does not take them into account in the lesson examples that it provides. This suggests that teachers can possibly assume that it is not important to identify or take into account the children's preconceptions when teaching Natural Sciences. These results are very important because all the participants of the study identified this book as the main guidance they have when teaching Natural Sciences.

Finally, as teacher 2 reported, the reference book can be a very useful tool for teachers since, as she said, “Before the Reference Book was published I was unsure about how to teach Natural Sciences, but now the Natural Sciences lessons that I teach are very similar to the ones described in the Reference book.” Thus, it is worth recognising that the specific reference book has encouraged teachers to teach the specific subject more often and also to teach topics that they did not teach in the past.

7. 2. 4. Main Results deriving from Second Phase of Analysis

The analysis of the interviews, the focus groups and the observations gave a number of results that will be taken through to the next chapter for further discussion. Similar to what happened for the first phase of data analysis, the main results deriving from the second phase of data analysis are listed below to help the reader identify and remember them. The main results that will need further discussion are the following:

7. 1. 4. a. Main Results based on the Interviews and the Focus Groups

1. Total number of 11 participants with a mean of 15.8 years of teaching experience and all of them work in public schools and have attended Natural Sciences seminars or conferences (except for teacher 9).
2. All participants agreed that there is a need for more seminars and conferences to be organised during working hours.
3. Most participants have graduated from the pedagogical Academy and from the University of Cyprus.

4. Most participants did not study science at high school.
5. The 3 participants that studied science at high school stated that this makes them more positive towards Natural Sciences and feel more confident when teaching Natural Sciences.
6. Most participants seemed to have a rather negative or neutral attitude towards Natural Sciences.
7. All participants agreed that the ‘Reference Book’ for early-years’ teachers is the main resource for teaching Natural Sciences.
8. Most participants are not satisfied with the equipment provided by their schools.
9. All participants agreed that there is a need for fewer children in each class, more materials and better equipment and books.
10. All participants agreed that the classroom environment is very important for a Natural Sciences lesson and all classrooms were arranged in the same way.

In regard to the teachers’ topic preferences:

11. Teachers are free to choose the topics that they want to teach based on the Cypriot National Curriculum and they tend to teach similar topics and avoid others.
12. All participants admitted that there are some topics which they avoid to teach because of their lack of subject knowledge.
13. Participants tend to teach the ‘Water Cycle’, ‘Plants & Animals’, ‘Human Body’ and ‘Matter’ more often and they tend to avoid teaching ‘Electricity’, ‘Light & Shadows’ and ‘Sound’.

In regard to teaching Natural Sciences:

14. Most participants reported that the best way to begin a Natural Sciences lesson is with a discussion-prediction part and the best way to finish it is with a summarising-evaluating part.
15. All participants say that it is very important to always prepare for a Natural Sciences lesson and have a lesson plan with clear learning objectives.
16. All participants agreed that Natural Sciences need to be taught at least once a week, but this does not always happen.
17. Most participants believe that experiments and role play are the most 'effective' methods to teach Natural Sciences.
18. Most participants agreed that they need more time to prepare for a Natural Sciences lesson in comparison to other subjects.

In regard to preconceptions:

19. Most participants agreed that the aim of the pre-primary school is to help and guide children to develop their skills rather than correct their preconceptions.
20. All participants agreed that children do not arrive at school as 'tabula rasa' (without any previous knowledge/concepts/preconceptions).
21. All participants agreed that there is a need for better training during student teachers' training in regard to Natural Sciences and preconceptions.
22. The children's preconceptions do not seem to be part of the teachers' training.

23. All participants agreed that it is helpful to be aware of the children’s preconceptions about a Natural Sciences topic that they plan to teach.
24. Only four participants said that it is important for teachers to identify the children’s preconceptions.
25. Most participants admitted that they sometimes assume a certain base of knowledge for all children and they sometimes might think that children know something when they actually do not.
26. Most participants considered that preconceptions do not affect the children’s learning.
27. More than half participants agreed that it is ok for children to leave pre-primary school and still have preconceptions.
28. Most participants said that they do not do something specific to help children correct their preconceptions.
29. Only 3 participants identified experiments as a good response to the children’s preconceptions.
30. The most common examples of children’s preconceptions given by the participants were that ‘Rain comes from God’ and ‘It rains because God is angry/ is crying’.

7. 2. 4. b. Main Results based on the Observations

1. A total of 6 participants were observed with a mean of 19 years of teaching experience and a mean of 20 children in their classrooms (maximum=25).
2. Most teachers did not study science during high school.

3. All of them have attended at least one seminar about Natural Sciences.
4. Only half of them said that they feel confident when teaching sciences.
5. All of them handed their lesson plan on the day of the observation with clear learning objectives.
6. None of them included a specific learning objective or activity about the children's preconceptions in the lesson plan.
7. Only teacher 11 started her lesson with an activity aiming to identify the children's prior knowledge and preconceptions (the list of ideas).
8. Only two teachers dedicated time to work on the children's preconceptions.
9. Preconceptions were expressed by children during all observations.
10. The most common preconceptions expressed by the children were:
    a. "God cries and it rains'
    b. "Clouds are made of cotton"
    c. "Water is white" (vocabulary issue)
    d. "Hot water becomes smoke" (vocabulary issue)

All the results presented in this chapter are taken forward to the next chapter to be further discussed and connected to the literature review.

7. 2. 4. c. Main Results based on the Document Analysis

1. The document analysed entitled 'Natural Sciences in Kindergarten: Reference Book for Kindergarten Teacher' edited by the Ministry of Education does not make any reference to the children's preconceptions.

2. Teachers need to plan lessons that will respond to their own interests and to the children's interests, as well.
3. The reference book does not take the children's preconceptions into account in the lesson examples provided in the book.
4. The children's prior knowledge needs to be taken into account when planning a lesson.

8. Discussion and Suggestions

This final chapter draws together the findings of the study and attempts to connect them with the literature review. This chapter is based on the results that derived from the data collected and comes together to address the research questions. In order to facilitate the discussion, research questions which are connected are addressed together. Each response is based on the results and compared to the existing literature. Finally, the discussion of each question includes specific suggestions for policy, practice and, in some cases, further research.

It is worth highlighting that the data collected allowed all the research questions to be addressed and revealed interesting issues in regard to Cypriot early-years' teaching of Natural Sciences and the appreciation of the children's preconceptions, which are discussed later on. The discussion will begin by firstly addressing the sub-questions which will lead to the main question and, finally, any further issues will be discussed.

8. 1. Teachers' Identification of Children's Preconceptions

The first sub-questions to be addressed and discussed are numbers 1, 2 and 3 and they are answered together since they all have to do with the teachers' identification of the children's preconceptions. To address these questions, we need to triangulate the results deriving from the key informants' interviews, the face to face interviews, the focus groups and the observations. Based on the key informants' responses, teachers do not tend to identify the children's preconceptions. The key informants suggest that this might occur because teachers do not believe that it is worth identifying the children's preconceptions and also because most of them do not have the necessary skills. As Mr Tom specifically stated "I do not think that early-years' teachers identify the children's preconceptions because they do not think that it is important to do so and some early-years' teachers do not even know what preconceptions are".

Back in 1984, Happs reported that few teachers disagree that to address preconceptions, they first need to identify them. The data from this study suggests that only a few teachers in Cyprus actually do something to identify the children's preconceptions, even if they recognise the importance of actually identifying the children's preconceptions. During the lesson observations, only one teacher included an activity with which to attempt to identify the children's preconceptions in her lesson.

The issue is that, if a lesson begins with the teacher ignoring the children's prior knowledge and preconceptions, it is very likely that the children will misunderstand or make erroneous links between their preconceptions with the new knowledge, and as a result they will end up with a new preconception. This is supported by Hanuscin's (2007) declaration that a new preconception can arise when a pre-existing preconception and a new concept get mixed up. However, the above could be avoided if teachers included activities at the beginning of the lesson which would elicit identification of the children's preconceptions.

Since teachers recognise the importance of identifying the children's preconceptions, a possible explanation of why teachers do not tend to identify the children's preconceptions is because they do not have the skills required (they do not know how) since most of them were not trained to do this. Another possible explanation could be linked to the issues Chen, Kirkby and Morin reported in 2006, that teachers do not usually have the time to identify the children's preconceptions and, thus they assume a certain base level of children's knowledge. This was also supported by teacher 11 who said that "Teachers often assume a certain basis of knowledge for all children and suppose that children know something when they actually do not." Teacher 6 added that "We can identify which children have problems, but we have trouble dealing with these specific children individually because we do not have enough time." Thus, it is possible that the pressure that teachers feel because of the many topics that they want to cover in a small period of time affects the children's learning of science negatively. Teacher 1 also agreed that the time pressure that teachers feel is not helpful and that a lot of time is wasted on school celebrations and when children should be doing their lessons, they do rehearsals, instead.

It is worth noting that it would be more appropriate and helpful to do so at the beginning of a Natural Sciences lesson to establish the whole lesson on the preconceptions that the children will express. Only then will teachers be able to actually guide and help the children correct and overcome their preconceptions. For example, teacher 9 stated that 'It is very important for a teacher to be aware of the preconceptions students have because when children have preconceptions, it is more difficult for them to understand the correct concept and they cannot follow the lesson'. Thus, identifying preconceptions in the middle or at the end of the lesson would be more helpful for evaluation and would allow establishing the lesson beginning with the children's preconceptions.

Based on the observations, the only teacher that identified the children's preconceptions was teacher 11, with the use of a brainstorming activity. Some ideas for activities that teachers can use to identify the children's preconceptions before the beginning of a Natural Sciences lesson are presented here. Similar to teacher 11, teachers can also use brainstorming activities which enable children to freely share their concepts. A practical way to identify the children's preconceptions is with the use of open-ended questions that will start a conversation about the topic being taught. Children can also express their concepts easily when they are shown pictures related to the topic being taught; teachers can ask open-ended questions to give the children the opportunity to express what they believe, in order to identify what preconceptions children have. For example, teachers can use questions like: 'What do you think that this picture shows?', 'What do you know about this?', 'What more would you like to learn about this?'. Open-ended questions will help to initiate a conversation that will enable teachers to identify the children's preconceptions.

The children's drawings are also helpful because they can be used to identify what children believe or know. Drawings can also be used as a diagnostic or final activity in a lesson to find out what children have learnt. Of course, it is not enough to let children draw; it would be more helpful to also ask children to give an explanation of what they are drawing. For example, teachers 6 and 12 included an activity like this at the end of their lesson and I grabbed the opportunity to go around and ask the children to explain their drawings (after kindly requesting for the teachers' permission). Based on the children's answers, I realised that three out of the four children that I talked to were not able to explain the phenomenon of the ‘Water Cycle’ despite the fact that they were able to draw a picture about it. Thus, it is important to talk to children and not just ask them to draw a picture without discussing with them. Particularly, when working with young children, the narrative that goes alongside the drawings, allows the teacher to increase access to the children’s thinking. Some children were kind enough to let me take a photo of their drawing as well and these are available at the appendix (see appendix 8).

Another way to see if children have any preconceptions is to present them with common preconceptions that occur and relate to a specific topic or pictures and observe how children will react and what they will say (for example will they accept the preconceptions presented?). Thus, it would be helpful for teachers to be aware of what preconceptions children usually have in regard to the topics being taught in early-years’ Natural Sciences or even have a list of them. Word walls is another good way to help children express their concepts and remember key points of the lesson; according to Jackson, Tripp and Cox (2011) interactive word walls provide an overview of the lesson and children can help to provide this overview by expressing their concepts. Teachers need to remember that they should make children feel comfortable and safe to express their concepts without pointing out who is right and who is wrong.

In addition, the majority of teachers believe that they are aware of the importance of identifying the children’s preconceptions but are not always able to explain why appreciating preconceptions is important. As a result, teachers may believe that they recognise the importance of the children’s preconceptions when they actually do not. The main reason for teachers to identify the children’s preconceptions should be the fact that preconceptions can affect the children's learning negatively. This happens because preconceptions can make it more difficult for children to accept, learn and remember the correct and new concepts presented and this is supported by the work of Stepans (1994) and Stepans and Kuehn (1995). Teachers, however, are not aware of these obstacles created by preconceptions and may avoid or decide that it is not necessary to acknowledge and consider the children's preconceptions during instruction. This can affect the children's learning who will not be able to achieve the learning objectives and the lesson will fail to match the children's developmental learning address or remediate the children's preconceptions.

There was one teacher in my sample who supported the opinion that preconceptions do not affect the children's learning. Specifically, teacher 2 stated that: "A child with a preconception will learn just like the rest of the class. The preconception will not affect the child's learning procedure". This specific teacher may be an isolated incident; on the other hand, when considering the observations' results and the fact that only one teacher did actually identify the children's preconceptions, one can presume that more teachers might share teacher 2's opinion but did not express it during the interview. This should worry researchers, teachers, university instructors, experts and people who are interested in early-years' education since it suggests that teachers need to be better informed about preconceptions and the disadvantages, the obstacles and the difficulties that they can have; teachers must recognise and understand the necessity to train to identify the children's preconceptions prior to instruction.

8. 2. Teachers' Reaction to Children's Preconceptions

The fourth sub-question to be addressed and discussed requires information about how teachers work with the children's preconceptions expressed during a lesson. This includes preconceptions that are expressed at the beginning, in the middle or at the end of a lesson. To address this question, we need to triangulate the results deriving mainly from the face to face interviews, the focus groups and the observations.

Based on the literature review, a lesson and the way that it is organised can affect the children's learning and their ability to get over their preconceptions (Atherton, 2009; Hoover, 1996). However, the results indicate that the overwhelming majority of teachers does not in any way use the preconceptions expressed by children during a lesson. This was indicated through the interviews and the focus groups. Like teacher 1, for example, who said that "Teachers often ignore preconceptions that are expressed during a lesson because they do not have time or because they have prepared and organised a different lesson". Teacher 6 also added that teachers cannot work with all children during a lesson to help them overcome their preconceptions because of lack of time.

The observations supported this perspective since only two teachers acknowledged the preconceptions that children expressed during the lesson and dedicated time to help children overcome their preconceptions. These were teachers 1 and 11 and it is worth noting that these two teachers a) studied science during high school and b) report that they feel confident when teaching Natural Sciences and c) they like teaching Natural Sciences. Teacher 11 also highlighted something that the rest of the teachers seem to overlook; "If teachers do not use the preconceptions expressed by children during a lesson, try them during the experiments, give examples, show pictures and use the proper objects to provide children with experiences that will prove to children that the concept in their mind is wrong, children will not be able to understand the correct concept". The results show that teachers usually seem to ignore the preconceptions expressed by children during a lesson and just follow their planned lesson without making any changes. However, teachers seem to disregard what Schmidt (1997) highlighted more than fifteen years ago; ignoring the children's preconceptions and hoping that they will overcome them on their own is unfair.

The analysis of the interviews and the focus groups also suggest that teachers think that they do not need to plan their lessons in a way that will help children eliminate their preconceptions. For example, teacher 7 said that "I have never planned a lesson so far considering the children's preconceptions". In addition, teacher 8 believes that children should be left free to use their imagination and teachers should not try to help them overcome their preconceptions because this would harm the children's imagination. This indicates that teachers do not understand that Natural Sciences is a subject that aims to promote the children's scientific thinking and facts rather than promoting their imagination. Children's imagination is motivated through other subjects and it is important to consider the children's preconceptions when planning and teaching a Natural Sciences lesson. It also indicates that teachers do not realise that children construct their knowledge, which means that, if children have preconceptions, they will not have the correct basis to construct their knowledge and learn the new concepts they are taught (constructivism).

As before, the fact that teachers say that they recognise the importance of the children's preconceptions when they actually do not and the fact that children need to construct new knowledge on previous knowledge which is free of preconceptions should worry teachers and those responsible for education extensively. Teachers should remember that children need to be actively involved in the learning process and that activities should aim at constructing new concepts based on children's previous concepts and preconceptions (Harlen, 1992; Harlen, 1999; Harlen & Jelly, 1997). Teachers should not only be better informed about preconceptions, but they should also be better trained and prepared to work with the children's preconceptions in a way that will help children overcome them. All teachers should keep in mind what teacher 1 reported during the interview: "Teachers cannot start a lesson and ignore who they are teaching and what they know, what experiences children have. Teachers need to know the children's preconceptions in order to help them eliminate them and construct their knowledge on what they already know." As she said "Children are not tabula rasa; they come with a lot of unorganised knowledge and teachers need to understand this."

8. 3. Teachers' Training about Natural Sciences and Preconceptions

The sub-question about the kind of training teachers receive about the children's preconceptions is mostly answered by the results deriving from the key informants' interviews, the interviews and the focus groups. Based on the key informants' interviews, the teachers' training does not usually include anything specific on the children's preconceptions. This happens because the professors teaching the subject of Natural Sciences in Cypriot and Greek universities and colleges are not obliged to include the children's preconceptions in their teaching. The two key informants that were interviewed explained that they include preconceptions in their teaching because they choose to do so, but other instructors might not do the same.

The interviews and the focus groups came to support this since, based on the teachers' responses, the devastating majority of teachers did not receive any training at all about the children's preconceptions. The only teacher that received training in regard to the children's preconceptions was teacher 9, who was the most recently qualified teacher of the study and his instructor was one of the key informants that were interviewed. Even worse, it seems that all those teachers that completed their studies at the Pedagogical Academy, a percentage of 23,8%, did not receive any specific training about Natural Sciences at all.

Fortunately, nowadays all student teachers are trained to teach Natural Sciences, but, sadly, preconceptions are not covered by all professors. It seems that only a small percentage of teachers have the opportunity to talk and learn something about the children's preconceptions during their studies. Teacher 8 specifically said: "The truth is that although I have heard children expressing preconceptions during a lesson several times, I had never thought how I could eliminate these preconceptions before now." This shows that there are in-service teachers who do not know how they can help children overcome their preconceptions because they have not been trained to do so and because nobody has ever talked to them about this.

It is worth mentioning that teacher 9, who was also the only man, completed his studies seven years ago and has only two years of teaching experience. In Cyprus, teachers cannot start working in public schools as soon as they finish their studies, because there is a waiting list. In the meantime, teachers can work in private schools or they can do something irrelevant to their studies. All qualified teachers who wish to work in public schools need to wait for their turn. There are specific criteria based on which teachers are awarded both points and a place (known as number) on the catalogue. The criteria are 1) the year of graduation, 2) age, 3) working experience in private schools (if any), 4) any further qualifications (e.g. Master's degree) and 5) completion of military service (for men).

As a result, teacher 9 started working after only five years because he also has a Master's degree which gave him extra points, in addition to his working experience gained in private schools. He has also been awarded extra points because of his age and the fact that he has completed his military service. This means that the rest of the teachers that graduated the same year as teacher 9 may still be waiting. The problem is that the catalogue is getting longer each year, which means that teachers that will graduate this year, for example, might need to wait for more than thirty or forty years to get a place in a public school.

The long teachers' waiting list which has more than two thousand two hundred and forty (2240) qualified teachers is a result of a decision made by the government of 2003-2008, when the Minister of Education and Culture was Pefkios Georgiadis. The decision made was that the college degree of pre-primary education is equivalent to the university degree of pre-primary education. Before that, only the teachers who graduated from a Greek or Cypriot University could be added on the catalogue and the government along with the universities were responsible to decide how many students should be accepted to study for this degree each year. In this way, the catalogue was not long and pre-primary teachers did not have to wait for more than a couple of years before they could start working in public schools. Teachers that graduated from private Cypriot colleges could work in private kindergartens or they could do some extra lessons in the public university, so that their degree would be recognised as an equivalent to a university degree. After the decision made, though, all teachers who graduated from Cypriot colleges (which were then entitled as private universities) could also be added to the catalogue. This transformed the catalogue into a long waiting list of teachers.

This long waiting list has a great impact on Cyprus and the educational system. Public pre-primary schools do not have the opportunity to employ new qualified teachers who are characterised by their new concepts, their spirit and their enthusiasm since teachers will have to wait for years before they can work at a public school. This also means that most probably, by the time teachers will have the opportunity to work in a public school, they will have forgotten what they learnt during their studies, especially if they choose to do something irrelevant to teaching and education while waiting. In addition, after so many years of waiting, it is also very possible that some things will be different (e.g. the curriculum) and that new methods, ideas and knowledge will be required.

Teachers who wish to work in public schools need to be patient and also keep up-to-date about education changes in policy and practice. They can do this by reading relevant articles, participating in different seminars and conferences which take place every year, study for a Master's degree and work in private schools or at other positions which are relevant to education. The ones making the decisions for the educational system in Cyprus should also be aware that their decisions affect people's lives directly and should not only accept the fact that problems exist but they should also do something to resolve them. This study does not aim to find a solution to this specific problem but other studies could be done because this is an issue that should be solved.

The positive thing is that, according to teacher 8, the discussion that we had during the focus group helped her. As she said "I feel that after this discussion, I can determine the preconceptions that children have and pay more attention to them and to how to work with children to help them". Similarly, teacher 10 also said that "The discussion that we had gave a lot of ideas about what I can do with my children to help them express and overcome their preconception." This is very positive for this study as it proves that teachers were happy to participate and that the study has helped them to express their ideas and listen to other teachers' ideas as well, especially within the focus groups. It also proves that if teachers benefited from a simple discussion during a focus group, they would definitely be benefited from relevant seminars and conferences. That is why, the responsible organisations, which are mainly the Pedagogical Institute and the University of Cyprus, need to organise educational seminars, conferences and events in regard to Natural Sciences and the children's preconceptions. These should take place during teachers' working hours since, based on what they teachers say, they will be more able to attend if they do not have to dedicate their personal time.

8. 4. Teachers' Response to Children's Preconceptions

Based on the literature review and the results discussed so far, most teachers acknowledge that a) children arrive at schools with preconceptions and b) children find certain scientific concepts difficult to understand (Farrow, 1999; de Boo, 2000; Farmery, 2002). The main research question is the one to be addressed next and refers to the teachers' response to teachers who do this. To discuss this issue the results deriving from all the research methods were triangulated. Emphasis was given to the results deriving from the interviews and the focus groups in comparison to the observations made to confirm if the way teachers act in the classroom are the same as the way they describe.

During the focus group and the interviews, the teachers were asked to list the methods they use to teach Natural Sciences. The teacher's most popular answer was 'experiment'; as teacher 4 explained "Experiments are useful because children can see things". Teachers seem to identify this method as 'effective' for a number of reasons. For example, teachers believe that experiments are 'effective' for those children who have a language barrier because they use their senses to learn and experience things, even if they do not understand the language very well. More children are identified each year as having language problems. These children could be identified as 'Limited Greek Proficient', which means that Greek is not their first language. Similar to other countries, this growing number of children who need additional language support requires extra time and effort by teachers (Allen & Park, 2011; Bergman, 2011). Early-years' teachers need to find out ways to encourage and help these children to participate in Natural Sciences lessons, and the use of experiments is a good way to accomplish this. Teacher 11 supported this suggestion since based on her experience, children whose first language is not Greek like experiments because they can understand better and, thus are more encouraged to participate in the lesson.

Another reason why teachers identify 'experiments' as an 'effective' method to teach 'natural science' is that through experiments children can try different things to test their ideas and preconceptions. When teacher 1 was specifically asked to explain why she included an experiment in her lesson, she answered that "I try to use a lot of objects and experiments so that children will experience the phenomenon that we are investigating. For example, when we are talking about rain and evaporation I usually do the following experiment: we boil water while holding a frozen plate above the saucepan where the water is boiling and in this way children are able to see with their own eyes that when the water boils, it evaporates and it becomes steam, because they can see the steam on the plate, and then they see that the steam becomes water again on the frozen plate and drops from it. The fact that they see it happening in front of their eyes helps them remember it and understand it better".

Teacher 7 agreed and said that experiments are a very good method to try out the concepts and preconceptions that children express during a lesson. She said that "When children experience something through their senses, they believe it and learn it." Teachers seem to believe that "experiments" is a good method to respond to the children's preconceptions because when children have the opportunity to experience and try out their preconceptions, they are able to decide for themselves what is right and what is wrong. Based on the observations, though, it seems that experiments are not frequently used by teachers, since only two of the participants chose to include an experiment in their lesson. It is also worth mentioning that both teachers did the same experiment. Since there was hot water involved which was dangerous for the children, the experiment was performed by the teachers while the children were watching.

Two more methods that teachers identified as 'effective' methods to use when teaching Natural Sciences were 'Role Play' and the use of 'Models'. According to the participants, these two methods are especially useful in the cases where experiments cannot be used. For example, teacher 9 uses 'Role play' to help the children understand the electrical circuit and teacher 1 uses 'Models' to help children understand the movement of the Earth around itself and around the Sun. The observations suggest that teachers do not often use these methods since none of the teachers used 'Models' and only one teacher used 'Role play'. Nonetheless, in the case where 'Role play' was used, this was to summarise the lesson.

Teachers also supported the opinion that having children working in groups is helpful when teaching Natural Sciences. Small groups can give the children the opportunity to see materials and experiment in their groups, discuss, present their results in the rest of the classroom, compare their results with the others and come to conclusions. However, during the observations none of the teachers used 'Group work', either.

An additional method, which was not identified or used by any of the teachers, is the one of ‘Cognitive conflict’. ‘Cognitive conflict’ is considered to be a very helpful method when it comes to eliminating the children’s preconceptions and was also supported by Mr Tom during the key informants’ interviews. It refers to presenting children with something which is puzzling or unexpected and which will force them to stop to think. It is not about presenting difficult material; it is more about leading to certain expectations which are then not met, so children will have to ‘think again’.

As it has already been said, the current Cypriot national curriculum is based on Piaget’s developmental views of learning and ‘guided discovery’, which was his main philosophical perspective (Nicolaou & Kiriakidou, 1996). For Piaget cognitive conflict was one of the main drivers of cognitive development (Atherton, 2009). If a child is always presented with work that can be easily done, there is little stimulation of the mind. Thus, ‘cognitive conflict’ is about organising activities that will offer the children the challenges which will be a little beyond their existing level of understanding, in order to encourage and push children to achieve higher levels of thinking. To achieve this, the organised activities need to lie within the children’s 'Zone of Proximal Development' (Leat & Nichols, 1997). Thus, teachers will need to identify what a child can achieve without help and what with some leading questions and guidance.

‘Cognitive conflict’ has been proven to be beneficial of all children, no matter their level of abilities (Shayer & Adhami, 2004). This means that lower ability children will not be disregarded when this method is used. Based on Shayer (1999), children with different ability levels can benefit from activities which are based on ‘cognitive conflict’, as the activities allow children to enter different levels by encouraging them to think and work in higher levels, ones that they used to work and do what they feel comfortable to do.

On the contrary, teachers seem to use ‘Story telling’ more often than the methods that they identify as ‘effective to teach Natural Sciences’. This is something that should worry teachers since most fairy tales use non-scientific vocabulary and this might confuse children. For example, teacher 12 used a fairy tale called ‘The feathered cloud’ which used no scientific vocabulary (like ‘the cloud is made of feathers’). Similarly, the fairy tales used by teachers 4 and 2 also included many phrases which were not scientific and could confuse children, like ‘the cloud started crying’ or ‘the water drop wanted to travel’. Teachers can use stories to teach Natural Sciences but they need to be very careful to choose stories that will not confuse children. It would also be better to explain to children that fairy tales use metaphors and clear up some phrases which might confuse children, like for example explain that in reality clouds are not made of feathers. Finally, it might be more appropriate to use story combinations with other methods rather than base the whole lesson on a fairy tale, which does not use scientific vocabulary.

Teachers can also use evaluative activities at the end of their lesson to determine what children have learnt. Teachers 1, 6, 11 and 12 had an activity at the end of the lesson which was an evaluative one, since it aimed to find out what children had learnt and not just summarise the lesson like other teachers did. For example, teachers 1 and 11 had a discussion with children which aimed to examine which children could explain the water cycle in their own words and with the use of pictures. In addition, teacher 6 requested children to complete and colour a worksheet with pictures about the ‘water cycle’. Teacher 6 was kind enough to allow me to have a brief conversation with children and also take some photos of the children’s work which are available at the appendices (see appendix 9). Based on the children’s work and in addition to the conversation that I had with the children, I realised that only six out of the eighteen that participated in this evaluative activity were able to complete the worksheet correctly and also explain the phenomenon of the ‘Water Cycle’. This indicates even more the importance of evaluating what children have learnt after the end of the lesson to be able to help children improve their skills and correct and develop their knowledge. This is even more important when the classroom consists of children of different ages, since in Cyprus there are classrooms of children from three and a half to five and a half years old, which also indicates an issue about the match or mismatch of the level of work required.

The results also revealed that teachers do not plan their lesson based on the children’s preconceptions and do not aim to help children clear up their preconceptions. Most teachers supported this during the interviews and the focus groups. More specifically, teacher 2 explained that “My lessons do not aim to eliminate the children’s preconceptions. My aim is to help the children use their prior knowledge and make them question the concepts that they expressed and were ‘incorrect’ through observations, experiments, questioning and hypothesis checking. An experienced teacher knows what issues are difficult for children to understand and what preconceptions they usually have. You do not need to organise a specific lesson to help them; you just do it. The important thing is to take advantage of the several opportunities that appear, for example, during the breaks or the play time'. A lesson that would include observations, experiments, questioning and hypothesis checking would be a lesson that could help children overcome their preconceptions. However, the specific teacher did not include any of the above in her lesson when she was observed since she based her lesson on a fairy tale and ended it with role play.

The fact that teacher 2 is an example of a teacher with many years of experience (similar to the rest of the teachers that supported the same opinion) might indicate that teachers who have many years of teaching experience end up planning their lessons based on specific ideas, like the children's prior knowledge or the children's preconceptions, but without realising it. It is obvious that the statements made by the teacher above involve theories that have to do with the children's preconceptions and methods that would help to dissolve them but the specific teachers did not realise it. For example, she refers to helping children to experiment, observe and question their own concepts, something which is very similar to 'cognitive conflict' discussed before.

On the other hand, teachers with fewer years of teaching experience seem to plan their lessons after a lot of thinking and preparation. For example, teacher 9 explained that 'First, I will see what preconceptions the children have and then I will plan the lesson in a way that will help them get over those preconceptions. This usually means that I will use a lot of experiments, things that children will be able to observe; at this age, it is very important to experience things through their senses. If they can see, touch, taste, listen and smell something, then it is much easier for them to comprehend it. For example, this year we have been observing the changes that a tree goes through during the year. We began in November and now it is May and we are still observing, taking notes and drawing the trees. This has helped the children realise the different seasons and how they affect trees and it was much more interesting than having me talking about this for a few hours and then expecting them to understand'.

According to Feiman-Nemser (2003), the early-years' teaching are a special time in a teacher's career, different from what has gone before and what comes after. Feiman-Nemser (2003) identified that before new qualified teachers begin teaching, they go through an initial phase of learning. This could explain the fact that teachers with fewer years of experience give more attention to theories of learning in contrast to other teachers. An additional explanation might be the different training that the teachers received since teachers with more than twenty three (23) years of teaching experience studied at the Pedagogical Academy instead of the University of Cyprus, which was established in 1989. Teachers with fewer than twenty three (23) years of teaching experience, who graduated from the University of Cyprus seem to be thinking more carefully when planning a lesson and follow the ideas and principles that they were taught in the university in a stricter way. Their lessons have more clear and scientific learning objectives and they use methods which are more appropriate when considering the children's preconceptions.

Furthermore, early-years' teachers do not only need to prepare the lesson; they also need to prepare themselves. Based on the results, most early-years' teachers do not have a scientific background and, therefore, they need to study and be well-prepared in order to teach Natural Sciences. The participants in the study supported the opinion that early-years' teachers need to study the topics they are planning to teach in depth. As teacher 3 said "When teachers know what they want to teach and have studied about it, they feel more confident and this will lead to a more successful and better lesson. In contrast, when they are not sure about what they are teaching, there is a feeling of fear and children can sense this and the lesson will fail. In such a case, there is also the danger of creating preconceptions to children because of the teacher's insufficient knowledge. If the teachers are not sure about something or if they hold the same preconceptions as children, the children will not manage to overcome their preconception." As a consequence, teachers need to study, read several books and articles and search for information that will help them identify and overcome their own preconceptions. Only if teachers manage to clear up their own preconceptions and are kept well-informed throughout the years, they will be able to help children learn science and clear up their preconceptions and as a result construct their knowledge on strong and correct bases which will assist the acquisition of new scientific concepts.

Early-years' teachers can also seek for advice and assistance about teaching natural science from their colleagues and the headteacher of their school, as well. The participants of this study revealed that they find advice, suggestions and instructions given by the headteacher of their school very helpful. As teacher 5 noted "Other teachers might have studied science in more depth or might have a relevant qualification, like a Master's degree, and the headteacher of the school will definitely have more experience than the rest of the colleagues. So, I believe that teachers should use the knowledge of their headteacher and the ideas of other colleagues, as well.' As a result, discussions and lesson observations between teachers can prove to be very supportive and useful. Teachers can exchange ideas and help each other to promote science teaching in their classroom and school. Observing others teaching can help to identify different ways of teaching a topic and borrowing ideas that will help to enrich or even improve science teaching.

Teachers are also requesting more seminars and conferences that will inform them about Natural Sciences. Since a lot of teachers were trained for Natural Sciences and most of them were not trained or informed about the children's preconceptions, conferences and seminars are necessary to inform teachers and help continue their professional development.

Generally, the participants made suggestions which imply that early-years' teachers should use the autonomy given to them by the Ministry of Education to plan lessons and activities so that there will be smooth transition between them with link to other subjects and the children's preconceptions and prior knowledge, as well. Science should not be considered as something to be learnt only during a Natural Sciences lesson. It is important for teachers to use all the opportunities that arise throughout the school year to teach science, work on new ideas and find ways to help children overcome their preconceptions in an engaging and motivating way.

8. 5. Resources and Equipment for Natural Sciences teaching

The results indicate that ample resources and equipment are two issues which worry early-years' teachers. What teachers usually report when they talk about these issues, is that they need more resources and equipment. For example, teacher 1 stated that “Early-years’ teachers need more resources, like reference books, where they will be able to find examples of good enough activities to help children get over their preconceptions. The modules offered at the University of Cyprus during our studies are not enough to make us feel confident enough to teach Natural Sciences. So, I believe that we need more resources like the book ‘Natural Sciences in Kindergarten: Reference Book for Kindergarten Teacher’ edited by the Ministry of Education. I use this book a lot to get ideas and activities which I appropriately change and use with children. But, we need more than this.” In addition, teacher 5 said that “Pre-Primary Schools do not have the necessary equipment to teach all Natural Sciences topics and, more often than not, teachers try to find them on their own.” The above indicate that early-years’ teachers are not satisfied with the resources and equipment available to them.

Teachers have the freedom to use any resource or book that they find useful and there is a big variety of resources and books available in libraries, bookstores and online. Teacher 6 agreed that having access to different kinds of resources, is much easier today in comparison to a few years ago, and early-years’ teachers should take advantage of this. However, besides the huge variety, the teachers’ basic resource when teaching Natural Sciences seems to be almost always the ‘Reference Book for Pre-primary Education’. Based on the document analysis though, this reference book does not take into account the children’s preconceptions. Thus, early-years’ teachers need to use additional books and resources to improve their teaching and not just one single reference book.

For example, teachers can use primary science books to find helpful ideas, examples of activities and experiments and also information to develop their subject knowledge. Teacher 8 was kind enough to share the details of some books that she finds useful and which are the following:

1) "Science experiments at pre-primary education" written by Aggeliki Thanu and

2) "Experiences and Activities in Natural Sciences" written by Lazaro Gavala and F. Lavrentaki Mpuka.

Still, even if these are mostly Greek books, teachers can find useful ideas which they can use in their lessons. As a result, teachers that use the reference book for Natural Sciences need to use other books to support their knowledge. They always need to remember to identify and take into account the children's preconceptions when teaching any of the lessons from examples presented in the specific book. It is agreed that this book is useful if is properly used, since it covers a range of different topics which are included in the National Curriculum.

In addition, teachers also believe that their schools do not provide them with the necessary equipment to teach Natural Sciences. According to the teachers, the lack of school equipment can make Natural Sciences a difficult subject to teach since equipment is necessary for the experiments. On the other hand, both key informants agreed that early-years' teachers do not need any specific materials or equipment to teach a topic or to carry out experiments.

It is true that children learn through their senses and need to see, touch, smell and taste different things and experiment, discover and learn. This does not mean that each kindergarten has to provide teachers with all the materials and equipment that they need. What the schools are required to provide is the specialised equipment which needs to be bought. According to Mr Ken, though, "All schools have the necessary specialised equipment but teachers usually find it hard to collect the non-specialised equipment that they need for an experiment". Mr Tom agreed and also explained that teachers do not have to use specific equipment and that they need to learn how to use materials that they can easily be found for their experiments.

Reference books and resources that will take into account the children's preconceptions are also necessary. The participants of this study also asked for a resource that will provide them with examples of activities that they can use to respond to the children's preconceptions and examples of the children's common preconceptions that will help them to identify preconceptions and save time. Teachers can also make use of resources that already exist and take advantage of the many ideas and useful activities that they could shape based on the needs and the preconceptions of the children in their class.

8. 6. Teachers' Attitude and Knowledge towards Natural Sciences

The results indicate that early-years' teachers' attitude towards Natural Sciences as a subject seem to affect their confidence when they have to teach the specific subject. For example, teacher 1 said that she does not like teaching Natural Sciences, does not feel confident when teaching the specific subject and she believes that this might be due to the fact that she did not study science at high school. Similarly, most teachers who did not study science during high school might not feel confident when teaching Natural Sciences. Yet, teachers 1, 9 and 11 who studied science in high school, all agreed that they like teaching Natural Sciences and they also feel confident while teaching it.

This might imply that those teachers who chose science as one of the main subjects to study in high school are teachers who have a positive attitude towards Natural Sciences as a subject today. In addition, it is possible that the fact that they studied science in the past makes them feel more confident when teaching Natural Sciences today. This reminds us of the Space Project's results (Russell & Watt, 1992); the results showed that, even if teachers should not feel that they are responsible to answer all the questions that children have, teachers often worry that they might not be able to give children answers to their questions. Teachers that studied science during high school might feel that they have the background and the scientific knowledge to help children find answers to their questions and, possibly, this makes them feel more confident when teaching Natural Sciences.

On the other hand, the results show that, even if the majority of the in-service teachers did not study science during high school, they have a positive attitude towards Natural Sciences since they state that they like teaching Natural Sciences. This however, might be due to the teaching experience since teachers may have been teaching long enough to make them feel confident when teaching the subject. Most teachers have also attended a series of regular and relevant seminars which aimed to inform teachers and give them several examples to enable them to plan and teach Natural Sciences' lessons.

8. 7. Teachers' Familiarity with Children's Preconceptions

An interesting result of this study is that early-years' teachers in general seem to know what the children's preconceptions are since they were able to talk and answer questions about this issue. Most early-years' teachers are able to explain what preconceptions are even if they might not always be able to distinguish between preconceptions and the children's prior knowledge. As a result, when teachers are asked to give a definition of 'preconceptions', instead of referring to the incorrect concepts that children have, they might include all the concepts that children have. For example, when teacher 1 was asked to give her own definition, she stated that "I would call them 'Experiences' because it is what children experience and the teacher is responsible to correct them, if necessary. They are concepts that some might be correct and some might be wrong. I could also call them 'Initial concepts' because they will change in the future but I think that 'Experiences' is more correct." Most responses were similar to this one, thus, teachers might believe that 'preconceptions' refer to all the concepts that children have.

Similarly, the teachers that participated in the focus groups were asked to give their own definitions about 'preconceptions'. The first definition decided by the participants of the first focus group was that 'Preconceptions are the children's explanations about a scientific phenomenon which usually emanates from their imagination. Since children do not have enough knowledge to know how to explain a phenomenon, their explanation is wrong - depending on their experiences as well.' This definition, like the ones given during the interviews, does not make clear the fact that children's preconceptions only refer to children's wrong concepts.

On the other hand, teachers 9, 10 and 11 were able to give a correct definition since they agreed that "'Preconceptions' are the children's own concepts for a phenomenon that do not agree with what is generally accepted in science, but they are logical for children'. This indicates that there is a percentage of teachers who is fully aware of what 'preconceptions' are. It is worth mentioning though that these specific teachers completed their studies at a public university and not at the Pedagogical Academy or at a private university. This might suggest that teachers who studied in public universities might have more opportunities to become better informed about preconceptions.

8. 8. Children's Common Preconceptions

According to Stepans (1994) teachers need to keep in mind that when they are aware of children's preconceptions, the curriculum, instruction and assessment are significantly improved. So, in an effort to help teachers, this study tries to make a list of the children's common preconceptions in regard to the 'Water Cycle'. This list includes the examples of children's preconceptions that the teachers gave during the interviews and the focus groups which were compared to the preconceptions expressed by the children during the observations. This comparison confirmed that some preconceptions are repeated by children and also that most of the preconceptions identified appear in lists of other countries as well, like the one provided by the American Institute of Physics in 1998. This suggests that children around the world share similar preconceptions. However, the list below is specifically produced based on data collected in Cyprus, thus, they are more applicable for Cypriot early-years' kindergarten classrooms.

The list below is the result of the comparison described above. Based on the results, the children's common preconceptions in regard to the 'Water Cycle' are:

- Rain occurs when clouds are shaken.

- It rains when the sun hides and the clouds crash together.
- It rains when clouds are crying.
- The sun boils the sea to create water vapour.
- It rains because we wish or pray for rain.
- Sky makes clouds
- Clouds and rain can be any colour like red, purple, pink, green, blue etc
- Clouds are made of feathers
- Clouds cry and we have rain
- Clouds are made of cotton.
- Clouds are made from steam that comes from the kettles (and the water that we boil in our houses in general e.g. for cooking).
- Clouds can follow us.
- God cries and it rains / Rain drops are God's teardrops.
- God makes rain and clouds.
- God / Jesus makes clouds.
- It rains when God is angry.
- Rain comes from God.
- Water can disappear.
- When water evaporates, it disappears.
- Hot water becomes smoke.

The above list of common preconceptions that children usually have about the 'Water Cycle' can help teachers save time and identify the children's actual preconceptions, as well. For example, they can present some examples of preconceptions that children usually have related to the topic that they plan to teach and discuss these with the children. This can help teachers identify children's preconceptions. More similar list about the different topics taught based on the Natural Sciences curriculum will also be useful for teachers.

8. 9. Teachers' Opinion about how Preconceptions are created

It is worth mentioning that when the teachers were asked to give their own label or definition about children's preconceptions, they also included an explanation about how preconceptions can be created. All teachers agreed about the fact that children have these concepts for a reason. Different teachers might give different explanation of how preconceptions are created. Based on the results, the explanations that teachers usually give is that preconceptions are mostly created based on the interaction that children have with their family members and friends and the children's everyday experiences. Teacher 1 correctly pointed out that children do not believe something without a specific reason and that children's preconceptions are created based on their experiences. Based on the literature review, many authors, like Driver et al. (1994), Johnston and Gray (1999) and Worth (2000) agreed with this since they said that preconceptions are based on the children's early experiences.

Some teachers might also believe that preconceptions are affected and can be created if teachers do not use the appropriate teaching methods. Teacher 11 agreed and explained that some preconceptions are due to the way that a specific science concept is taught. As she said, "Usually children have some ideas about the 'Water Cycle'; they usually know that when we have grey clouds and the sun 'hides', it will rain and this is what most teachers say when teaching this topic.

But, there are more things that affect this phenomenon, like for example humidity. Children have preconceptions about the ‘Water Cycle’ because teachers do not make it clear that there are other things that affect rain, apart from the sun and the clouds”.

However, teachers are usually not familiar with the fact that preconceptions can be transferred between individuals and that children who have preconceptions are not aware that their concepts are not correct. As a result, children who hold such incorrect concepts can convince others in a group to believe them as well (Snyder & Sullivan, 1995). Similarly, teachers can pass their own alternative concepts to children, as well. According to what Mr Tom said during the key informants’ interviews, teachers are also responsible for children’s preconceptions, even if they do not do it on purpose. As he said “It is not the teachers’ fault that they have alternative concepts themselves. This opinion was also supported by Johnston (2005) who added that teachers should be aware of their own alternative concepts, as well. She said that “I believe that I have a lot of alternative concepts and I think that the fact that I have never studied science in the past has a lot to do with this. That is why I always study well before teaching something because I want to be sure that I will not pass any of my alternative concepts to children.’ As a result, teachers should study the subject topic that they want to teach very well, identify their own alternative concepts and clear them up in order to be able to organise a proper Natural Sciences lesson.

Teachers also often fail to recognise the importance of the language used during a Natural Sciences lesson. According to Hanuscin (2007), language can confuse children and lead to preconceptions when common words which are used in everyday life are also used during Natural Sciences but with a different meaning. For example, teacher 12 used the fairy tale "The feathered Cloud'; this fairy tale included many phrases (like the feathered cloud) and many metaphors (like the cloud started crying) which can be very confusing for children.

Also, the fact that fairy tales sometimes give human characteristics to things like the sun or the clouds can also lead to preconceptions. For example, teacher 5 said that "Children believe that it rains when God gets angry and when clouds crash. They connect the 'Water Cycle' with God very much because we always say that God lives in the sky and also because when we make the morning pray we ask from God to send us rain, especially now that we have problems in Cyprus because it never rains'.

The above examples involve children giving human characteristics to God or clouds and they are also connected with the experiences that children have every day; as 'Interviewee 8' said, the fact that every morning children pray to God for rain makes them believe that God is the only condition needed in order to have rain. Also, the way that the specific subject of rain is taught, affects the way that children think. For example, if, while teaching this subject a teacher presents pictures with clouds that have faces and cry, the children will believe that clouds are like humans and cry. Finally, teacher 10 said that "When we begin to talk about rain and the 'Water Cycle', children are waiting to see an actual cycle or a circle made of water. They also wonder why it does not fall on us but only the rain does if the cloud becomes heavy when it is full with steam."

All the above prove that the language used during a Natural Sciences lesson can be very confusing for children and that is why teachers need to be very careful and choose their words with caution. Teachers need to be aware of how central their important role is since their own concepts, their actions, the lessons they plan and the language they use can lead to children ending up with preconceptions.

8. 10. Teachers' Topic Preferences

As it has already been said, based on Cyprus' pre-primary National Curriculum, teachers are free to choose the topics that they want to teach and the time that they want to devote on each topic and on Natural Sciences in general. This kind of freedom can be seen as positive if teachers use it with wisdom to benefit children's learning. However, this freedom can end up damaging Natural Sciences and the children's learning when teachers choose not to teach some topics at all, even if the curriculum says that all subjects must be taught. For example, teacher 2 stated that "I have never taught 'Electricity' so far because I do not feel confident and since we are free to choose what to teach, I avoid it." Teacher 1 agreed with this and also believed that the National Curriculum should have different topics. For example, as she said "Electricity is something that should be covered in pre-primary science education. But, of course we are not obliged to teach all the topics that are mentioned in the curriculum. We are free to choose what we want to teach and how often."

Based on the results, teachers seem to prefer teaching specific topics, like 'Weather-Earth-Space' (including the 'Water Cycle'), 'Plants & Animals', 'Human Body' and 'Materials', whereas they seem to avoid teaching other topics, like 'Electricity', 'Light and Shadows', 'Sound' and 'Heat and Energy'. Mr Ken agreed completely with the teachers that some topics are easier to teach than others, while, on the other hand, Mr Tom supported that there are not easy or difficult topics to teach and as he said “It depends on how well a teacher knows a specific topic to make it easy or difficult to teach”.

In an attempt to explain these topic preferences, some teachers might say that they do not have the necessary materials or equipment to teach some topics. For example, teachers 1 and 4 said that they do not like teaching ‘Electricity’ because they do not have the necessary materials to teach it. However, as it has already been discussed, there are no specific material or equipment necessary for a topic to be taught since teachers can find different ways and use different materials to teach a topic when they wish to do so.

Some teachers suggested that they choose to teach some specific topics, not only because they feel more confident and because they have better subject knowledge, but also because the children prefer some specific topics more than others. For example, teacher 1 said that “Because children can do a lot of things, they can be active and engage, it is not just me talking and them repeating. I do not like it when I am talking and children are just listening. I prefer to have a lesson in which children can work in groups, try things by themselves when it is safe.” Teacher 3 similarly said that she prefers some topics “Because you can do a lot of things that children can see and this topic is more understandable by children.”

However, when taking into account all the results that derive from this case study, it seems that a more possible explanation of the teachers’ topic preferences is the fact that teachers feel more confident to teach some specific topics in comparison to others. According to what teachers say, teachers believe that a topic is easy to teach when they believe that they have good subject knowledge about that topic; then, they feel more confident to teach it and they teach it more often. On the other hand, when teachers find a topic more difficult to teach than is usually because they have difficulties in understanding that specific topic themselves and might also have alternative concepts for that topic, as well; thus they feel less confident to teach it and as a result they avoid teaching it.

In other words, teachers hesitate to teach topics that they do not know well perhaps because they fear that they might not be able to answer the children's questions and will end up confusing children. The view of teaching and learning articulated here is a transmission model where the teacher is expected to know all the answers. Teachers who have alternative concepts or do not like a specific topic might believe that children will not like that topic either, or will have difficulties which might lead to creating preconceptions to children. Teachers 2, 3, 4 and 5 all said that they avoid teaching 'Electricity' and 'Light' because they feel that their knowledge is not sufficient and they are afraid to teach these topics. Based on the results, teachers 2, 3, 4 and 5 are not the only ones that feel like this since the majority of the in-service teachers feel similar to them.

8. 11. Main Differences between Private and Public School Teachers

As it has already been said, the questionnaire was sent to 135 pre-primary schools, 75 of those were public kindergartens and 60 were private kindergartens. As a result, it was possible to make a comparison between private and public kindergartens. The results of this comparison revealed that teachers teaching at private kindergartens are more satisfied with their training during their studies and their subject knowledge in comparison to those teachers teaching at public kindergartens. Private kindergarten teachers also report to feel more confident when answering children's questions during a Natural Sciences lesson and are more satisfied with the equipment provided to them by the private school. On the contrary, teachers teaching in public kindergartens do not seem to be so satisfied with the equipment available and provided by their schools nor with their training or subject knowledge.

This comparison also revealed that usually private kindergartens have fewer children in each classroom compared to public kindergartens. This can affect the lesson procedure because it is better to have small groups of children since more things can be done without the teacher being concerned about classroom control. It might also affect the teachers' satisfaction and confidence when teaching the specific subject, since teachers might feel less confident when teaching a larger group of children because it is more difficult for them to manage the classroom and feel satisfied with the end of the lesson.

In addition, the comparison of the private and public kindergartens revealed that the mean of teaching experience for public schools is higher than for the private ones. This means that teachers who work in private schools are more recently qualified teachers in comparison to those teachers working in public schools. This might be another possible explanation for why teachers that teach in private kindergartens report that they feel more confident when teaching science in comparison to teachers teaching in public kindergartens. The fact that teachers who are teaching at public kindergartens have more years of experience than the ones teaching in private kindergarten schools means that they are older and they completed their studies earlier, and maybe at the Pedagogical Academy rather than at a University. As a result, teachers who work in public kindergartens will possibly feel less satisfied and less confident since most of them have studied at the Pedagogical Academy and were not trained in regard to Natural Sciences.

There are, however, some similarities between public and private kindergarten teachers, as well. For example, there are not any significant differences, between private and public kindergarten teachers in regard to their attitude toward science since their responses were similar:

a) I am confident about teaching Natural Sciences and

b) I like teaching Natural Sciences.

Moreover, the results do not indicate any difference between private kindergarten teachers and public kindergarten teachers' high school studies in regard to science. The majority of them seem to believe that their subject knowledge and their skills of teaching Natural Sciences today is irrelevant to the subjects that they studied during high school, which is not true based on the results of this study.

8. 12. General Suggestions deriving from this Case Study

The case study described here leads to some interesting suggestions that could increase the quality of teaching early-years' Natural Sciences and also gives some general implications to teachers and policy makers. First of all, the results of the study stress the importance of the teachers' role. It seems that the fact that children end up with preconceptions may mainly arise from their educators' actions. This includes the lesson and activity planning, the classroom organisation and environment and the educators' subject knowledge and behaviour in general. Children's experiences and thoughts depend a lot on their teachers' actions and beliefs as young children spend a lot of time with their early-years' teachers. Children usually tend to imitate their teachers and for them teachers act as role models. Thus, the teachers' behaviour and attitude towards science will affect children's attitude towards science a lot, as well (Johnston, 2005).

As a consequence, a suggestion for early-years' teachers and educators in general would be to act very carefully and select the correct and teaching methods, and suitable activities, equipment and materials based on the children's needs and interests. In addition, teachers should plan their lessons and activities with care and then take into account the children's preconceptions while they should also use their own behaviour and excitement to encourage the children's participation and knowledge construction.

Furthermore, the results of this case study appear to indicate that the teachers' scientific background is also important when talking about ways to help children eliminate and overcome their preconceptions. It seems that teachers who have good subject knowledge and scientific background (e.g. teachers who studied science during high school) feel more confident when teaching early-years Natural Sciences. Teachers also need to have good subject knowledge in order to help children overcome their preconceptions, clarify their thoughts and also avoid mixing up concepts which usually leads to the creation of new preconceptions (Hanuscin, 2007).

A suggestion for policy makers and educational leaders would be to ensure that early-years' teachers have studied some science and have an efficient scientific background before beginning their career as teachers. For example, students intending to study early-years' teaching could be examined in regard to their scientific knowledge before entering the university. Alternatively, more modules about Natural Sciences and children's preconceptions could be added and studied by future early-years' teachers. This would help future teachers to improve their scientific knowledge and acquire the necessary skills and knowledge to teach early-years' Natural Sciences. It would also help future teachers to feel more satisfied with their subject knowledge and more confident when teaching Natural Sciences. Teachers' confidence is very important because according to the results of this case study, confidence is very important for a teacher since teachers who feel more confident also teach in a way that helps children overcome their preconceptions. This is because they feel certain about what they say and they use correct language and vocabulary, as well. This is very important because the use of the appropriate vocabulary can help children since children can easily get confused when their teachers use words which can have a different meaning when used in everyday situations.

Additionally, this case study reveals the importance of the role that preconceptions have when it comes to children's learning and the acquisition of new concepts. Teachers should keep this in mind when planning a lesson and when teaching a new scientific concept since it is important to dedicate time to find out what preconceptions children have before teaching a new topic. This is essential not only for teachers but also for policy makers and educational leaders that need to consider this when developing and evaluating the national curriculum and also when deciding the amount and subjects of the different topics that teachers have to teach during an academic year. The results of this study suggest that the national curriculum should be revised and maybe some changes are necessary; thankfully this is currently happening since it is part of the current educational reformation. However, the ones responsible need to be extra careful to make changes that will take into account the problems and the needs of the early-years' teachers; changes that will help to improve the current situation and not make it worst.

Finally, this study provides teachers with information about teaching methods and ideas for activities which can be helpful and appropriate for Natural Sciences when applied based on children's needs and interests. Careful planning and preparation can assist to have more effective and affective early-years' Natural Sciences lessons. This study has also been proven to be important for teachers since it also describes a range of methods that teachers can use to identify children's preconceptions such as picture discussions or brain storming - list of ideas which have been previously discussed. One example of a poster on how teachers can make a list of ideas/ brain storming with children for the topic of 'Weather', about what they want to learn and how they can do that is presented in the appendices (see appendix 10). The study also suggested many methods that teachers can use to help children eliminate those preconceptions. This could be really helpful for teachers, especially new ones. One way is simply talking and asking questions in a whole class discussion. This can be useful for sharing ideas and identifying preconceptions, while allowing children to think of their own concepts, first, and, then, encouraging them to share their concepts with another child or in a group would be better because usually a group discussion does not always give the chance to all children to talk (Russell & Watt, 1992; Wallace, 2002).

As it has already been said, children's drawings are also helpful when identifying the children's preconceptions. Children's drawings reflect children's concepts and, thus, they give a better insight into what children think. They also give the teachers the opportunity to discuss with children the concepts that they have. It is important though to accompany these drawings with the children's narratives which will explain and help to clarify what has been represented. Teachers can also give the opportunity to children to express their views and preconceptions, which will be identified with the use of the methods already described, and then teachers can write down these preconceptions and keep them as a diary for each child individually. These diaries can help to follow and assess children's knowledge development and they can be used to record changes over a longer period of time (Russell & Watt, 1992).

It is very essential for teachers to involve children in procedures and activities which will require the use of the scientific skills, as suggested by Wallace (2002). These skills refer to children who observe, predict and communicate and in a following stage measure, hypothesise, plan and carry out fair tests and interpret results and findings. It is very helpful for children to be active and to test their ideas and concepts. This will encourage them to observe and report carefully what happens and to express their ideas and concepts about what happens and why. For example, when discussing a particular problem, the teacher can ask the children to suggest different solutions to the problem. Children should also be encouraged to think different contexts where the same issue can occur and also realise that solutions may vary. It is also helpful to discuss with children the words that they use to describe their concepts and get children to communicate their ideas and use correct vocabulary.

9. Limitations of the Study

Although this study was prepared with care and has achieved its aims, there are always some potential limitations. First of all, the questionnaires could have been sent to more schools, public and private, in order to gain further responses. Also, the use of questionnaire has proved to be very helpful for this study; however, it could help to collect more specific information about the teachers' appreciation and response to children's preconceptions, possibly if more open questions were included. Including more open-ended questions, though, could put at risk teachers' willingness to complete the questionnaires since it would require more time to answer the open ended questions. In addition, the study was conducted between private and public schools, and even if the main aim was not to compare these two types of schools, an equal number of private and public schools could participate so that we would be given the opportunity of comparison between provisions of early-years.

Furthermore, more interviews and focus groups could be conducted to increase the number of the research participants and potential of increased validity for the research outcomes. A series of observations could be carried out instead of just one observation for each teacher. This would help to have a more complete picture of how the specific topic of 'Water Cycle' is taught, since most of the teachers reported that more than one lesson are usually needed to cover this topic. The limitations described here are mainly due to lack of time, since this study is part of a doctorate degree which had to be completed within a specific time schedule; lack of money was another difficulty that needed to be addressed, since this study was not sponsored and all expenses were covered with personal cost.

This study focused on only one topic, out of the ten included in the Cypriot National Curriculum at the moment, to make it easier to investigate the issue of children's preconceptions. Finally, another limitation of this study is that it was conducted during an era of educational reformation in Cyprus. The educational reformation is something that happened unexpectedly and a lot of things can change after an educational reformation; these changes could not be predicted by the study and are still not clear since the reformation has not been completed, yet. Thus, there is a possibility that the changes that will take place after the completion of the educational reformation may affect the results of this study.

Considering the results and the limitations of this study, further studies need to be conducted that will acknowledge the changes of the educational reformation taking place. Further studies would involve more participants and also over a range of topics and scientific concepts aiming to further investigate the complex issue of children's preconceptions. Further research that would reveal children's most common preconceptions in regard to specific scientific topics and specific examples of how teachers can help children to overcome their preconceptions for each topic would be valuable and practical for teachers.

10. Conclusion

Educational research is not just a matter for teachers, despite their central role, as there are also policy makers, managers, support staff, teacher educators, examiners, inspectors and parents all of whom need educational research and its findings in order to act more intelligently (Hegarty, 1996). All these stakeholders have important knowledge to gain from educational research and their results, which can contribute to a better understanding of education. Whatever the future of institutional teaching and learning will be, one constant will remain, namely the need for high-quality research and development. Thus, we shall ensure that educational research does make its unique contribution to the enhancement of learning, whether in schools and other institutions or in society at large (Hegarty, 1996).

As a closure to this thesis, it is appropriate to talk about the contribution of this study. After a careful and detailed literature review and a well-planned case study, it was revealed that preconceptions exist and can be an obstacle for children's learning. The contribution of this study for teachers is that it has proved the importance of dedicating time to identify the exact prior knowledge and preconceptions children have prior to planning and teaching. It has also managed to provide teachers with specific examples of methods which can be used to teach Natural Sciences and can also help to respond to children's preconceptions. Finally, it has provided teachers with a list of children's common preconceptions about the 'Water Cycle'.

This multi-method case study has not only managed to uncover the importance of appreciating children's preconceptions, it has also elicited that just identifying children's preconceptions is not enough. Teachers need to be well trained and able to plan lessons and activities based on the preconceptions identified; the lessons need to be organised and planned in such a way to cause 'cognitive conflict' because only then children will be convinced about the correct concept and prevent the development of preconceptions into alternative concepts. The teacher is the one responsible for guiding children through the process of making children question conceptions they hold, how they articulate these and understand why and where they were "incorrect". Children need to be encouraged to test their concepts and develop more specific correct definitions for particular words. In other words, when children have preconceptions, addressing those preconceptions before learning can take place needs to be central to the practice of teaching.

It is worth mentioning that articles written based on this study have already been published (as an example the article presented at BERA conference 2010 and published by education – line in 2011 is available at the appendices - see appendix 11). This study has already been presented to a group of people in Cyprus who are actively involved in the decision making in regard to the teaching of Natural Sciences. Specifically, the study was presented to the 'Learning in Science Group' of the University of Cyprus which is a group of professors, lectures, researchers and masters' and doctoral students investigating several issues about teaching Natural Sciences. Some of the issues that this group are dealing with at the moment in regard to early-years science are: a) the review of the reference book used by early-years teachers in Cyprus, b) planning and evaluating activities and, c) review of the national curriculum. The presentation of the study managed to convince this group of the importance of the results and has offered me the opportunity to be part of this group today. This is of great importance as it indicates that the results of this study are accepted and appreciated from academic audience in Cyprus.

This job position at the University of Cyprus gives me the ability to actually do something about the issues identified from this study. For example I participate in the review of the reference book and I will contribute to its rewrite. I also play an important part in the planning and the evaluating activities that are designed for an online database that will be accessible for teachers from different European countries. Also, articles will be written, seminars organised and conferences attended to inform teachers about the new reference book, the educational reformation including the issues of preconceptions in science teaching and learning. This study has proven to be a major contribution for Cyprus as it is the first study that investigated teachers' appreciation of early-years children's preconceptions in science with this context and has managed to identify a problem that needs to be solved.

11. References

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12. Appendices

12. 1. The Questionnaire

Questionnaire

I am an early-year teacher and I am now doing my PhD in Education in Warwick University. My interest focuses on Natural Sciences and children's preconceptions. Thus, I decided to conduct a research to investigate teachers' views on children's preconceptions and their response. This questionnaire was designed to discover teachers' perceptions of teaching specific Natural Sciences' topics. Teachers will also be asked to give some personal information (e.g. years of experience).

All questionnaires will be anonymous and all information given by participants will be kept confidential. Participants are also informed of their right to withdraw at any moment. The whole questionnaire will take no longer than fifteen minutes to be completed. Please be as honest as you can because it is important to get a true picture of your perceptions.

Your co-operation is very much appreciated. Thank you.

Teacher's information:

In the items 1-6 put a √ in the appropriate box:

1. **Sex:** Male (1) □ Female (2) □
2. **Combination (or lessons) that you followed at secondary school:**

C.I: Klasiko□ C.II: Practiko □ CIII: Economico □ C.IV: Emporiko □

C.V: Foreign Languages □

If you went to Enieo Secondary School, please specify the 4 main lessons that you attended:

………………………………………………………………………………………….

3. **Length of teaching experience (including this year as one full year):**

   1 year□ 2-5 years□ 6-10 years□ 11-20 years□ 21 years or more□

4. **Class that you teach this year: reception □ 1st grade□ 2nd □ 3rd □ 4th □ 5th □ 6th □**

More than one age group. Specifically: ………………

5. **Approximately how many children are there in your class this year?**

   Fewer than 20 children□ 21-26 children□ 27 children or more□

6. **a. Type of school:** 1 teacher□ 2 teachers□ 3 teachers□ 4-5 teachers□ 6 teachers or more □

   b. Other characteristics of the school (please tick only one box):

Provinces	**Nicosia**	**Limassol**	**Larnaca**	**Paphos**	**Kyrenia**	**Famagusta**
Town						
Village						

7. **Country/place of graduation:**

University of Cyprus□ Pedagogical Academy of Cyprus□ College □ University in Greece□ Other: Please Specify ……………………………….

Part 2:

8. Please indicate how you feel about the next statements. Circle one answer in each line:

Statements	Very much (5)	Much (4)	Neutral (3)	A little (2)	Very little (1)	Not at All (0)
I am confident about teaching Natural Sciences	5	4	3	2	1	0
I like teaching Natural Science	5	4	3	2	1	0
I feel satisfied with the training I had during my studies	5	4	3	2	1	0
I feel satisfied with the knowledge obtained during my studies in regard to Natural Sciences	5	4	3	2	1	0
I feel that I was well-prepared to teach Natural Sciences when I finished my studies	5	4	3	2	1	0

I feel confident about answering the children's questions during a Natural Sciences lesson	**5**	**4**	**3**	**2**	**1**	**0**
I feel satisfied with the equipment I was provided from the school	**5**	**4**	**3**	**2**	**1**	**0**
I believe that the lessons I had in high school affect my ability to teach natural sciences today	**5**	**4**	**3**	**2**	**1**	**0**

Part 3:

9. **Please circle the answer that mostly expresses your opinion:**

Very much (5)	Much (4)	A little (3)	Very little (2)	Not at All (1)

a. **How confident do you feel about teaching:**

Plants and Animals	5	4	3	2	1
The human body	5	4	3	2	1
Weather – Earth - Space	5	4	3	2	1
Ecology	5	4	3	2	1
Matter	5	4	3	2	1
Magnets	5	4	3	2	1
Light	5	4	3	2	1
Sound	5	4	3	2	1
Heat - Energy	5	4	3	2	1
Electricity	5	4	3	2	1

b. **How satisfied do you feel with your knowledge on:**

Plants and Animals	5	4	3	2	1
The human body	5	4	3	2	1
Weather – Earth - Space	5	4	3	2	1
Ecology	5	4	3	2	1
Matter	5	4	3	2	1

Magnets	**5**	**4**	**3**	**2**	**1**
Light	**5**	**4**	**3**	**2**	**1**
Sound	**5**	**4**	**3**	**2**	**1**
Heat - Energy	**5**	**4**	**3**	**2**	**1**
Electricity	**5**	**4**	**3**	**2**	**1**

c. Please indicate how often you choose to teach the following topics:

Plants and Animals	**5**	**4**	**3**	**2**	**1**
The human body	**5**	**4**	**3**	**2**	**1**
Weather – Earth - Space	**5**	**4**	**3**	**2**	**1**
Ecology	**5**	**4**	**3**	**2**	**1**
Matter	**5**	**4**	**3**	**2**	**1**
Magnets	**5**	**4**	**3**	**2**	**1**
Light	**5**	**4**	**3**	**2**	**1**
Sound	**5**	**4**	**3**	**2**	**1**
Heat - Energy	**5**	**4**	**3**	**2**	**1**
Electricity	**5**	**4**	**3**	**2**	**1**

d. Please indicate the amount of misconceptions that children have in regard to the following subjects:

Plants and Animals	**5**	**4**	**3**	**2**	**1**
The human body	**5**	**4**	**3**	**2**	**1**
Weather – Earth - Space	**5**	**4**	**3**	**2**	**1**

Ecology	**5**	**4**	**3**	**2**	**1**
Matter	**5**	**4**	**3**	**2**	**1**
Magnets	**5**	**4**	**3**	**2**	**1**
Light	**5**	**4**	**3**	**2**	**1**
Sound	**5**	**4**	**3**	**2**	**1**
Heat - Energy	**5**	**4**	**3**	**2**	**1**
Electricity	**5**	**4**	**3**	**2**	**1**

10. Please rank the following statements according to how much they affect your teaching beginning with 1 as the factor that affects it the most and 5 the one that affects it the least:

Subject knowledge □

Resources available □

Time available □

Children's misconceptions □

Other: Please indicate: ……………………………□

11. If there is anything else that you would like to add or say, please do so in the space provided below

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

THANK YOU VERY MUCH FOR YOUR HELP

12. 2. Questions for Key Informants Interviews

Key Informants' Semi-Structure Interview- Questions:

I am an early-years' teacher and I am now doing my PhD in Education in Warwick University. My interest focuses on 'Natural Sciences' and children's preconceptions. Thus, I decided to conduct a research in regard to teachers' views on children's preconceptions and their response. This interview aims to collect important information in regard to what teachers are taught during their studies, especially in regard to preconceptions. It also aims to identify what current research in Cyprus is investigating in regard to this subject.

The interview participants will be kept anonymous and all information given will be kept confidential. You are also informed of your right to withdraw at any moment. The whole interview will take no longer than an hour. Please be us honest as you can.

Your co-operation is very much appreciated. Thank you.

1. Definitions for children's preconceptions and teachers response to them from the key individuals' point of view:

- What do you understand about children's misconceptions?
- How would you define them?
- What do you think that teachers' attitudes are about children's preconceptions?

- How do they define them?
- From you experience how do teachers deal with children's preconceptions?
- Is this how they should deal or do you think they should be doing something different?
- In your opinion in which science topic(s) do children have the most preconceptions?
- Does this make this subject more difficult for teachers to teach?
- Which topic(s) in science is/are the one that troubles teachers more when they have to teach it?

2. Universities' role during teachers' studies and afterwards:

- What does the university do that helps future teachers be able to cope with children's preconceptions?
- How do you support student teachers to deal with children's preconceptions?
- As a professor do you try to unpack possible preconceptions that students might have, during their studies?
- Do student teachers observe other teachers teaching science?
- Are student teachers observed teaching science? If yes from whom?
- What kind of feedback do they get back?
- Do they get any specific feedback on dealing with children's preconceptions?

- Do you require student teachers to submit any work specifically on children's preconceptions?
- Are there any differences between the training that primary teacher students and early years' teacher students receive during their studies in relation to science and children's preconceptions?
- Does the university provide any professional development for working teachers and how?
- Are there any seminars, conferences, programmes, courses etc that take place during the year that can help teachers enrich their knowledge and methods for teaching natural science and dealing with children's preconceptions?

3. Resources and the use of the Reference Book

- What kind of resources can early years' teachers and first grade primary school teachers use today to teach natural sciences?
- Do you believe that the Cypriot science reference book is a good book for early years' teachers to use for advice and help on lessons planning and children's preconceptions?
- What is your opinion about the science book that teachers use today at first grade primary school?
- Are there any resources that help teachers deal with children's preconceptions?

4. Individual input on Cyprus current position for natural sciences?

  - Do you feel that as an academic/ researcher you were/are able to have an input on the Cypriots Natural Sciences Curriculum content design and principles?
    - Do you think that you input was and can be effective?
  - Are you involved with any in service work about natural sciences?
- How do you think that the Cypriot national curriculum considers (if it does) children's misconceptions?

12. 3. **Observation Schedule** (this was printed in landscape)

1) Is there a science corner?

2) Does the lesson plan acknowledge children's alternative ideas?

3) Do any alternative ideas arise during the lesson?

The teacher is:	**0-5 minutes**	**5-10 minutes**	**10-15 minutes**
Initiating Discussion	□	□	□
Telling something (Story)	□	□	□
Questioning: 1)Open 2)Close	□ □	□ □	□ □
Answering: 1)Pupil's Question 2)Her own question	 □ □	 □ □	 □ □
Explaining a concept	□	□	□
Giving Instructions	□	□	□
Commenting on Activity	□	□	□
Demonstrating - Experiment: 1) Herself 2) Pupils	 □ □	 □ □	 □ □
Making a table/graph	□/□	□/□	□/□
Using models/ video/ pictures	□/□/□	□/□/□	□/□/□

Offer Analogy	□	□	□
Introducing Vocabulary	□	□	□
Using Role Play/ Drama	□	□	□
Giving Example(s)	□	□	□
Summarizing/Reviewing: 1)Herself 2)Pupils	□ □	□ □	□ □
Introducing Preconceptions:	□	□	□
Dealing with Preconceptions: 1) Acknowledge but ignore 2) Acknowledge and work on individual level 3) Acknowledge and work in group 4) Does not acknowledge	1) □ 2) □ 3) □ 4) □	1) □ 2) □ 3) □ 4) □	1) □ 2) □ 3) □ 4) □
Classroom Organisation: Circle/Groups/Couples/Lone working	□/□/□/□	□/□/ □/□	□/□/ □/□
General Comments			
The teacher is:	**15-20 minutes**	**20-25 minutes**	**25-30 minutes**
Initiating Discussion	□	□	□
Telling something (Story)	□	□	□
Questioning: 1)Open 2)Close	□ □	□ □	□ □
Answering: 1)Pupil's Question 2)Her own question	 □ □	 □ □	 □ □

Explaining a concept	□	□	□
Giving Instructions	□	□	□
Commenting on Activity	□	□	□
Demonstrating- Experiment: 1) Herself 2) Pupils	 □ □	 □ □	 □ □
Making a table/graph	□/□	□/□	□/□
Using models/ video/ pictures	□/□/□	□/□/□	□/□/□
Offer Analogy	□	□	□
Introducing Vocabulary	□	□	□
Using Role Play/ Drama	□	□	□
Giving Example(s)	□	□	□
Summarising/Reviewing: 1)Herself 2)Pupils	□ □	□ □	□ □
Introducing Alternative Concepts	□	□	□
Dealing with Alternative Concepts: 1) Acknowledge but ignore 2) Acknowledge and works on individual level 3) Acknowledge and works in group 4) Does not acknowledge	 1) □ 2) □ 3) □ 4) □	 1) □ 2) □ 3) □ 4) □	 1) □ 2) □ 3) □ 4) □

Classroom Organisation: Circle/Groups/Couples/Lone working	□/□/□/□	□/□/ □/□	□/□/ □/□
General Comments			
The teacher is:	**30-35 minutes**	**35-40 minutes**	**Extra Comments**
Initiating Discussion	□	□	
Telling something (Story)	□	□	
Questioning: 1)Open 2)Close	□ □	□ □	
Answering: 1)Pupil's Question 2)Her own question	 □ □	 □ □	
Explaining a concept	□	□	
Giving Instructions	□	□	
Commenting on Activity	□	□	
Demonstrating- Experiment: 1) Herself 2) Pupils	 □ □	 □ □	
Making a table/graph	□/□	□/□	
Using models/ video/ pictures	□/□/□	□/□/□	
Offer Analogy	□	□	
Introducing Vocabulary	□	□	

Using Role Play/ Drama	□	□	
Giving Example(s)	□	□	
Summarizing/Reviewing: 1)Herself 2)Pupils	□ □	□ □	
Introducing Alternative Concepts	□	□	
Dealing with Alternative Concepts: 1) Acknowledge but ignore 2) Acknowledge and works on individual level 3) Acknowledge and works in group 4) Does not acknowledge	 1) □ 2) □ 3) □ 4) □	 1) □ 2) □ 3) □ 4) □	
Classroom Organisation: Circle/Groups/Couples/Lone working	□/□/□/□	□/□/ □/□	
General Comments			

13. 4. Information Sheet for Observations

Observations - Information Sheet

This observation aims at discovering different methods that teachers use to teach the ‘Water Cycle can be taught’. I would like to take this opportunity and ask you to answer the following questions in order to help me observe the lesson more effectively. It will not take longer than three minutes.

Thank you very much for your co-operation.

- How long have you been teaching natural sciences? ☐
- Approximately how many children are in your class this year? ☐
- Did you study Science as a main subject during high school? ☐
- Have you participated in any seminars about ‘natural sciences’? ☐
- What do you use more often when you teach science?
    - Experiments ☐
    - Story - Fairy tale ☐
    - Other: .... ☐

- Please indicate the extent to which you agree with the following statements.

1=Strongly disagree 2=Disagree 3=Not sure 4=Agree 5= Strongly agree

1. I like teaching science.

   1 2 3 4 5

2. I feel confidence while teaching science.

   1 2 3 4 5

12. 5. Questions for Semi-Structured Interviews

Suggested Structure for the Interviews

1) What is science to you?
2) How many hours per week do you devote to prepare and teach for Natural Sciences?
3) How many hours per week does the curriculum require you to teach Natural Sciences?
4) What topics do you usually teach?
5) What topics do you like teaching or feel more confident to teach and why?
6) Do you believe that your background in regard to science (high school, seminars, and subject knowledge) affects the way you feel about science and the way you teach Natural Science and how?
7) How do you usually teach Natural Sciences and why?
8) How would you teach the 'Water Cycle'?
9) Some people suggest that many children develop their own 'theories' to explain nature and these theories can sometimes be substantially different from the so-called scientific theories. What do you think about this suggestion?
10) What can you tell me about 'children's preconceptions'?
11) What kind of training did you receive in regard to children's preconceptions during your studies?

12) Can you give me an example of a common preconception that children might have about ‘Water Cycle’?

13) Do you identify children’s preconceptions about a topic that you want to teach? How do you do that and when?

14) Do you believe that teachers should identify preconceptions about a topic that they want to teach and why?

15) How do you think that preconceptions can affect children’s understanding and learning procedure?

16) What do you do in order to help children overcome their preconceptions? What else could you do?

12. 6. Questions for Focus Groups

Suggested Structure for Focus Groups

1) What teaching methods do you consider to be more 'effective' for teaching science to early-year children? What methods do you use to teach Natural Sciences? Do you know what constructivism is?

2) Some people suggest that many children develop their own 'theories' to explain nature, and sometimes these theories can be substantially different from the so-called scientific theories. What do you think about this suggestion?

3) Now, I would like to ask you to write on the piece of paper that I have given you an example of these 'theories' that you believe the children have in regard to 'Water Cycle'. Then read it out loud and explain why you wrote that specific one.

4) Next, I would like us all together to decide and give a definition about children's theories which I call preconceptions in my research. I would like all of you to say what you believe and decide all together how we can best define children's preconceptions about scientific phenomena.

5) Now that we have talked about this, would you change anything about the way that you teach Natural Sciences? If yes, what would you do differently?

6) Finally, I would like to ask you to think and give me some suggestions and advice, that we could give to other early-year teachers about how we can help children eliminate their preconceptions.

12. 7. Table with the values of 'p' and 'r' based on the questionnaire

Subjects / Questions that have correlation	Plants & Animals	Human Body	Weather Earth Space	Ecology	Matter
Satisfaction with knowledge - Confidence to teach	**r= 0,596 p<0.01**	**r= 0,673 p<0.01**	**r= 0,839 p<0.01**	**r= 0,849 p<0.01**	**r= 0,813 p<0.01**
Frequency of teaching - Confidence to teach	**r= 0,333 p<0.01**	**r= 0,310 p<0.01**	**r= 0,347 p<0.01**	**r= 0,340 p<0.01**	**r= 0,568 p<0.01**
Frequency of teaching- Satisfaction with knowledge	**r= 0,437 p<0.01**	**r= 0,307 p<0.01**	**r= 0,409 p<0.01**	**r= 0,399 p<0.01**	**r= 0,538 p<0.01**
Confidence to teach- Children's preconceptions	**r= - 0,231 p<0.01**	**r= - 0,231 p<0.01**	r= -0,158 Not Signif.	r<0.001 Not Signif.	**r= - 0,266 p<0.01**
Children's preconceptions - Frequency of teaching	**r= - 0, 287 p<0.01**	**r= 0,296 p<0.01**	r= 0,038 Not Signif.	r= 0,139 Not Signif.	r= 0,101 Not Signif.
Children's preconceptions - Satisfaction with knowledge	r= 0,111 Not Signif.	r= -0,860 Not Signif.	r= -0,177 Not Signif.	r= 0,022 Not Signif.	r= -0,187 Not Signif.

Subjects / Questions that have correlation	Magnets	Light	Sound	Energy	Electricity
Satisfaction with knowledge - Confidence to teach	**r= 0,825 p<0.01**	**r= 0,833 p<0.01**	**r= 0,662 p<0.01**	**r= 0,775 p<0.01**	**r= 0,798 p<0.01**
Frequency of teaching - Confidence to teach	**r= 0,524 p<0.01**	**r= 0,430 p<0.01**	**r= 0,480 p<0.01**	**r= 0,473 p<0.01**	**r= 0,412 p<0.01**
Frequency of teaching- Satisfaction with knowledge	**r= 0,489 p<0.01**	**r= 0,451 p<0.01**	**r= 0,515 p<0.01**	**r= 0,585 p<0.01**	**r= 0,466 p<0.01**
Confidence to teach- Children's preconceptions	r= -0,031 Not Signif.	**r= - 0,212 p<0.01**	**r= - 0,211 p<0.01**	**r= - 0,363 p<0.01**	r= -0,034 Not Signif.
Children's preconceptions - Frequency of teaching	**r= 0,246 p<0.05**	r= 0,112 Not Signif.	r= 0,061 Not Signif.	r= -0,029 Not Signif.	r= 0,025 Not Signif.
Children's preconceptions - Satisfaction with knowledge	r= 0,026 Not Signif.	r= -0,043 Not Signif.	r= -0,031 Not Signif.	**r= -0,284 p<0.01**	**r= -0,261 p<0.01**

12. 8. Children's Drawings

Children's drawings from the observation of teacher 6, lesson 12 were a result of a final activity. The children were asked to explain their drawing. Their drawings are presented below together with their narrations.

Child 1 said: "I drew the sea and the sky and the cycle. The Sun heats the water drops because they are sad and the Sun is helping them to find their way to the cloud. When a lot of water will get in the cloud, it will become fat and it will start crying."

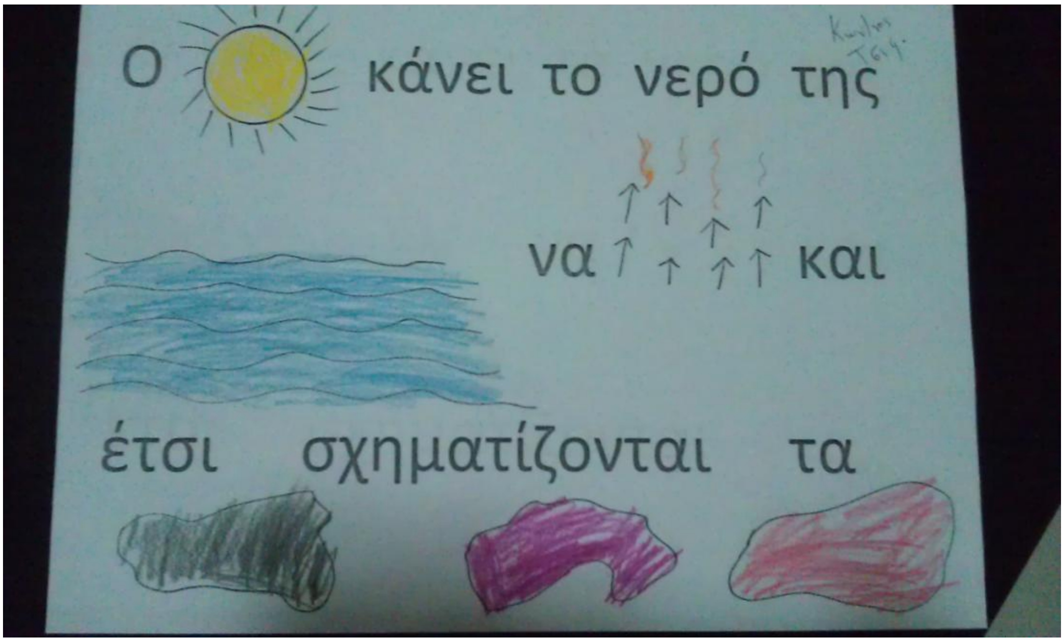
Child 2 said: "I drew a tree, a flower and a cloud that is raining. The rain drops go to the ground, to the sea and to the Sun. The Sun heats the rain drops and makes the water cycle and rain drops go to the clouds with the Sun. The Sun makes the water cycle in the sky."

Child 3 said: “I drew the cloud that is full of water and it became too fat and wanted to cry and then it started raining. The rain drops went to the ground, the sea and the rivers. Then the Sun will heat them and they will fly back to the cloud and the water cycle will help them to find their way there.”

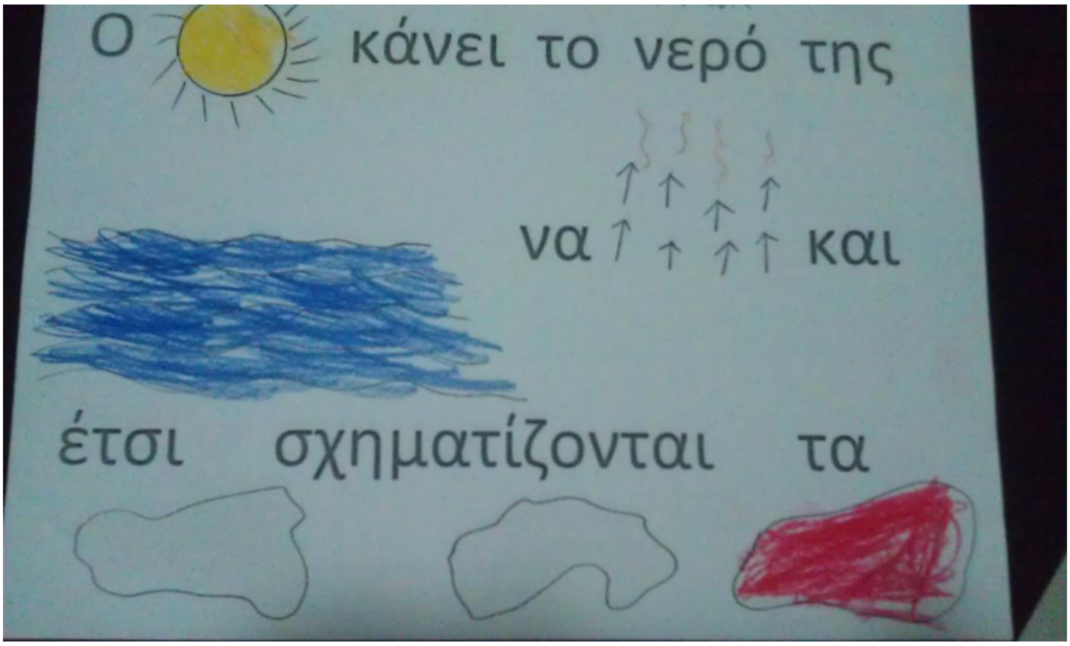
12. 9. Children's worksheets

Lesson 4 included an evaluative activity and children's work is presented below.

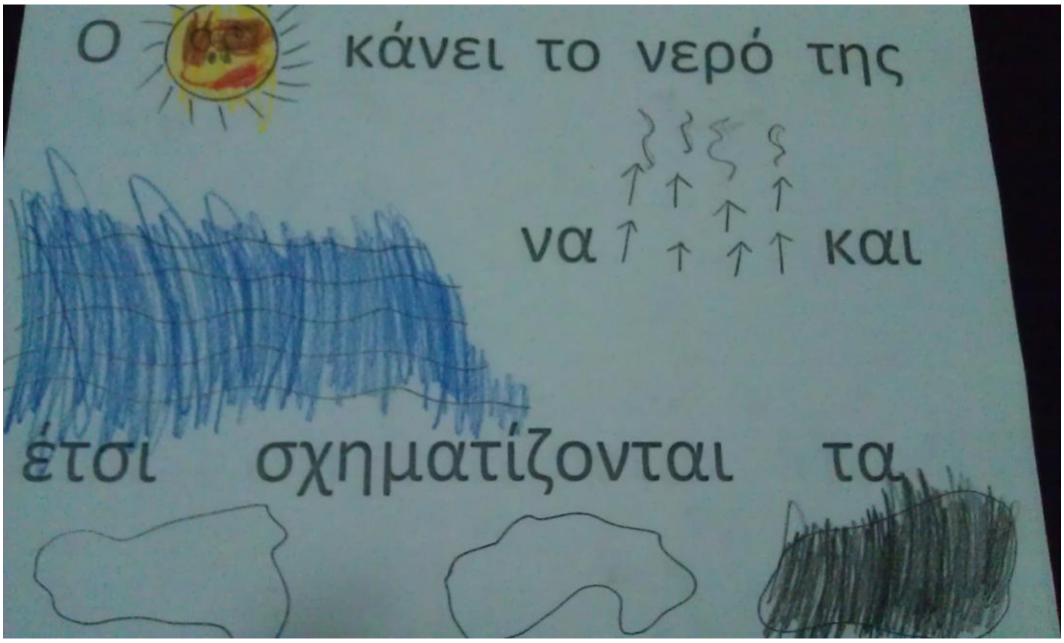
Child 1 said: "Clouds can be any colour you want."



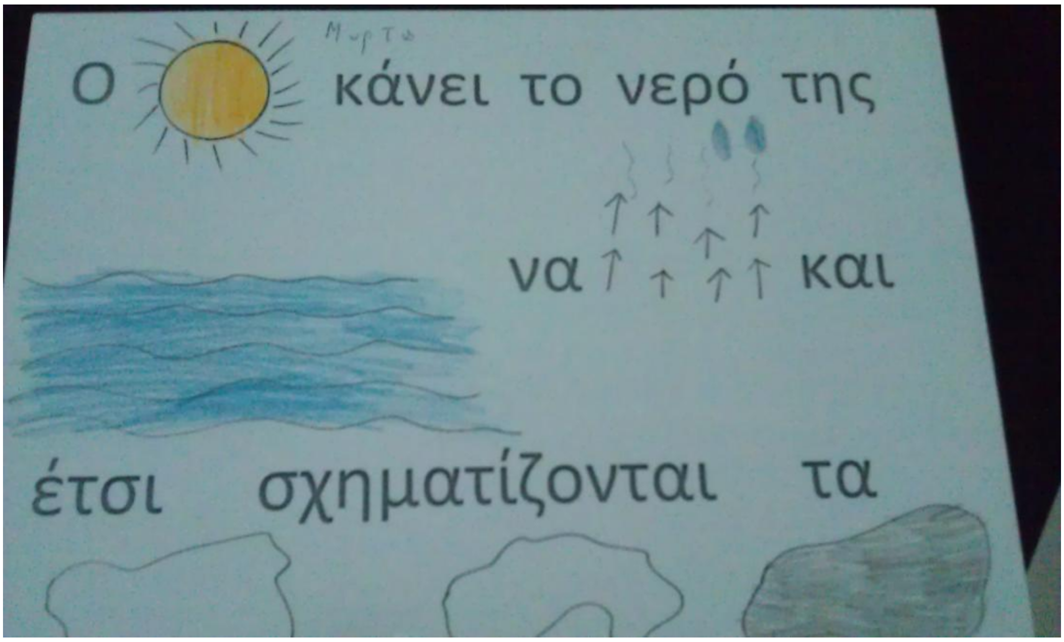
Child 2 said: "Clouds can be different colours and I like red."



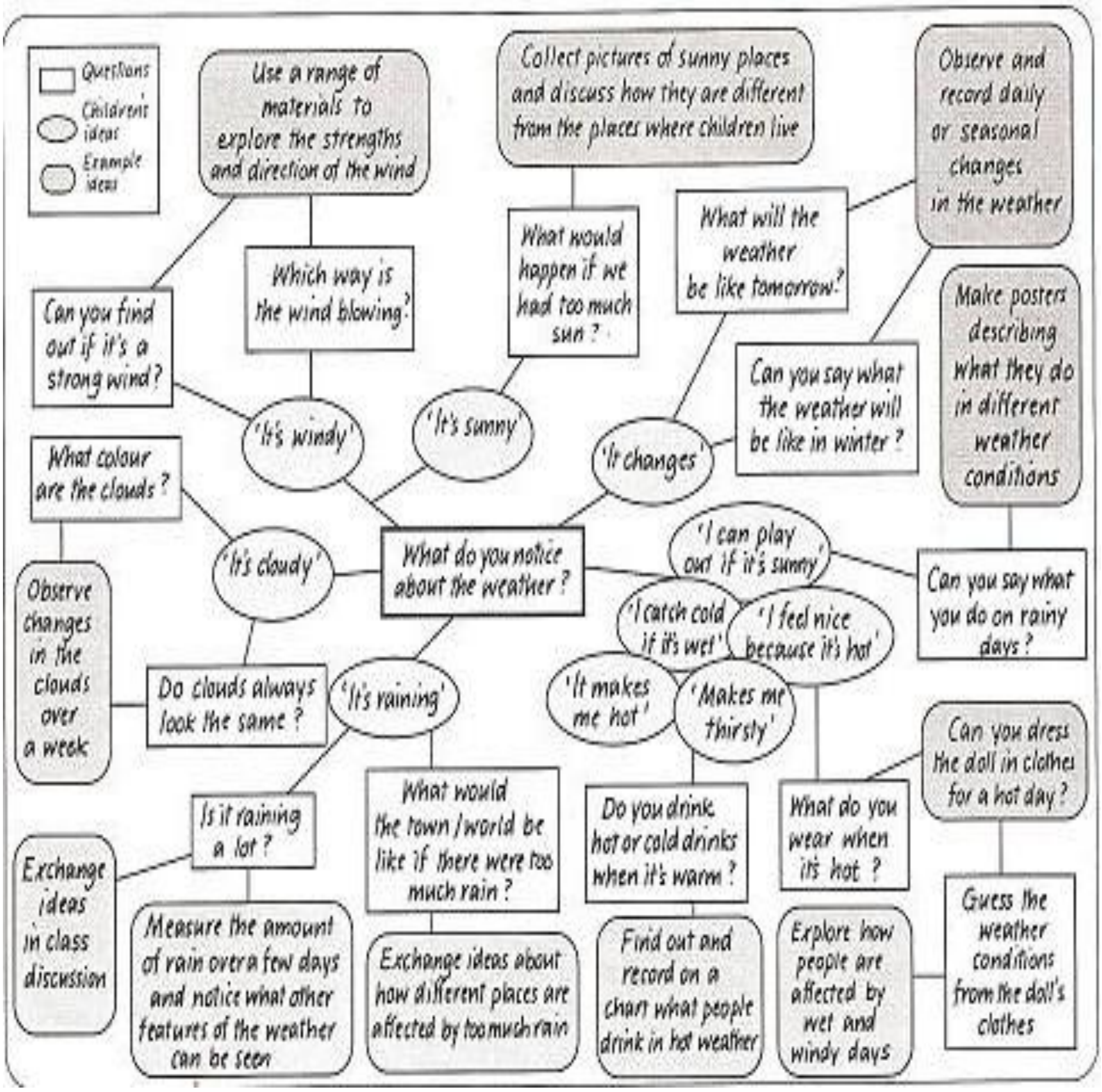
Child 3 said: “The Sun is very nice and helps the water to fly.”



Child 4 said: “The Sun and God help the water cycle.”



12. 10. Example of poster for 'Weather'



12. 11. Paper presented at BERA conference 2010 and Published by Education Line in 2011

EDUCATION-LINE

'Teachers and children's misconceptions in science'

Maria Kambouri – University of Warwick

Paper presented at the British Educational Research Association Annual Conference, University of Warwick, 1-4 September 2010

Abstract: Educators agree that everyday activities enable children to learn some science even before entering preschool education and that children's ideas are part of the classroom. Some of these ideas will not be completely correct; misconceptions refer to children's incorrect or incomplete ideas. This paper refers to research investigating teachers' response to early year's children's misconceptions in Cyprus. The results indicate that often teachers do not acknowledge the existence of these misconceptions and this is likely to be an obstacle for children's learning. The aim is that with the completion of this research more details will surface misconceptions and Cypriot education and hopefully future research will enlighten this new area of investigation for the Cypriot datum.

Introduction

Arguments in regard to whether or not children already have some knowledge and scientific concepts, before entering formal education are no longer necessary as the science education community generally accepts the idea that children enter the classroom with their own understanding of the world (Henriques, 2002). What is important to note is firstly, that this knowledge can and does affect children's school learning of science and secondly, some of this knowledge is incorrect and remarkably resistant to change (Black & Lucas, 1993). As Valanides (2000b) states many studies confirm that learners bring ideas into the classroom, which differ from those accepted by the scientific community. Thus, it would be acceptable to say that misconceptions exist, are held in multiple ways and often inconsistently applied by the children (Black & Lucas, 1993). Research into young children's misconceptions and initial knowledge will help teachers to face them and the sooner we study them the more effectively we can work with them (Ravanis & Bagakis, 1998).

A few words about Cyprus

This paper is examined Cypriot teachers and classrooms, therefore it was considered necessary to provide the reader with some useful information about Cyprus in order to have a better understanding of the research. In Cyprus, education is compulsory for the early years, beginning at the age of three years, and it is within the parents' jurisdiction to decide whether and when they should arrange a placement for their children in a public or private nursery school. The Cypriot national curriculum was firstly developed after Cyprus' independence from the British in the 1960's, with periodic reviews of fifteen years or more having been undertaken since then. In the pages of one book- curriculum both pre-primary and primary education are covered and science is one of the included topics as well maths, literacy, music, art and other topics. Sadly, the part devoted to the early years is no more that forty pages and it just gives a general description of the topics that should be taught alongside with the main objectives for each topic (Ministry of Education, 1996). As Valanides (2000b) notes, children's misconceptions are not addressed by the Cypriot curriculum, Cypriot textbooks, reference books or traditional instruction, as ‘we tend to teach as we were taught’. Consequently, these can constitute a significant obstacle to learning (Valanides, 2000b).

Teacher training in Cyprus started in 1987 with opening of the ‘Pedagogical Academy of the Ministry of Education’ which was the first public institution which trained kindergarten and primary school teachers (Solsten, 1991). Today, in-service pre-primary teachers may have graduated from the Pedagogical Academy of the Ministry of Education or from the University of Cyprus. They also might have studied at one of the recently qualified private universities in Cyprus or abroad, mainly in Greece and Britain. This implies that in-service as well as pre-service teachers receive different kinds of training and it can be difficult to track the science content or the instructional approaches.

Review of the Literature

The term ‘tabula rasa’, which indicates that children are blank slates and teachers need to fill them in with information, is not generally accepted anymore (Pine, Messer, John, 2001). This happens because children’s ideas are formed as the result of previous experiences and such experiences exist from the moment of birth. Such experiences become part of children’s scientific learning and come from various environments in and around their homes (Bradley, 1996). Jill de Kock (2005) agrees and adds that children’s scientific views are a result of personal experiences, which can include typical everyday activities like having a bath or watching television in addition to interaction with adults. As a result, some of children’s everyday activities will have enabled them to learn some science and will be part of the children making sense of their environment even before entering preschool education (Bradley, 1996).

The target of investigation for this research is the scientific ideas that children have when they enter formal education in Cyprus (pre-primary schools) which may be partially formed or scientifically inaccurate. According to Hamza and Wickman (2007), Helm (1980) labelled these ideas as 'misconceptions' while Ausubel (1968) and Novak (1977) chose to call them 'preconceptions' whereas Driver (1981) preferred the term 'alternative frameworks'. The term 'misconception' has an obvious connotation of 'a wrong idea' and research reported on common misconceptions in various areas of science indicates that this term is usually used in studies where children have been exposed to 'formal models or theories and have assimilated them incorrectly' (Driver & Easley, 1978, p.61). However, the term misconceptions will be used throughout this paper as it is the most commonly used term (Hamza & Wickman, 2007) and it will be used to refer to "children's ideas that differ from definitions and explanations accepted by scientists" (Schmidt, 1995, p1).

Ausubel (1968) was the first one to refer to children's misconceptions and noted that they are amazingly tenacious and resistant to extinction (cited in Driver & Easley, 1978). Misconceptions can often pose strong barriers to understanding physics and many of them are detrimental to learning (Clement, Brown & Zietsman, 1989). It is important to note that when teachers acknowledge children's misconceptions they can prepare lessons in order to use them for teaching and also potentially remedy them (Schmidt, 1995). However, according to Chen, Kirkby & Morin (2006), teachers rarely have the time to identify children's misconceptions and are often forced to take for granted a certain base level of their children's knowledge. Furthermore, teachers are concerned about their own subject knowledge, about not knowing enough and that children will ask them something and they will not be able to answer; they tend to believe that teaching is about having all the answers to children's questions (Chen, Kirkby & Morin, 2006). However, according to Russell and Watt (1992) something like that would be considered wrong since, frequently, the information given by teachers in such cases do not link into children experiences and thinking. This could also deter children from asking questions since they find that they cannot understand the answers (Russell & Watt, 1992).

School science should be about reaching possible conclusions by exploring relationships and explanations between ideas and events and it is essentially about understanding (Devereux, 2007). It also incorporates the testing of ideas and the proposal of original theories and questions, which change all the time as our ideas, skills and knowledge are developed through new research and data (Devereux, 2007). The Cypriot ministry of education (1996) agrees with this and points out that school science is about teaching children the skills they need in order to be able to observe, explore and experience events. These will help children to comprehend the world around them and how it works and also to arrive at possible and logical conclusions (Ministry of Education in Cyprus, 1996).

Additionally, Asoko (2002) highlighted that science teaching should involve a process of change in the thinking of the child-learner. A way to achieve this is by teaching science with the use of more practical and memorable experiences which can be more effective for children's learning; such experiences should involve a child centred approach that will take account of children's prior knowledge and misconceptions (Johnston & Gray, 1999). Rousseau was the first one to identify the importance of experiential learning and he also managed to convince educators for the importance of child- centred education; but Dewey as well recognized that children learn best when offered varied activities because they have different types of intelligence and learning needs (Johnston, 2005). However, we must be careful and not rush children from one experience to another because they will have little opportunity to “try out their developing ideas and build upon existing ones” (Johnston, 2005, p3). It is important to remember that in the early years children learn through trial and error and this takes time and patience (Johnston, 2005).

Teachers though, can only achieve this if they first clarify their personal understanding of science and apply this knowledge in their work in order to feel secure with their subject knowledge and pedagogic skills to teach each topic effectively. As Valanides (2000a) points out, studies suggest that teachers demonstrate a wide collection of misconceptions analogous to those of children. As he continues, when teachers are less knowledgeable about the topic they are also more likely to rely upon low-level question and to give their students less opportunities to speak. Consequently, misconceptions can arise as a result of children’s interaction with teachers (Gilbert & Zylberstajn, 1985) along with children’s contact with the physical and social world (Strauss, 1981) and textbooks and other sources used by teachers (Cho, Kahle & Nordland, 1985) (all cited in Valanides, 2000a).

As a result of this perspective, teacher education programs should try to familiarize teachers with common misconceptions children have and their effects on children’s learning procedure (Tirosh, 2000). Education programs also devote time and efforts in eliciting and building on teacher’s conceptions in order to accommodate for these conceptions during pre-service and in-service training (Valanides, 2000a).

Teachers' need to help children develop their scientific understanding, starting from ideas that they already have, through investigations of topics, discussions, explorations of children's ideas and experiences (Russell, & Watt, 1992). Teachers are responsible for guiding children through the learning process using the most effective methods of teaching. Additionally, teachers have to organize children's misconceptions into coherent concepts which are accurate and explicit. Howver, it is worth adding that in the early year's science is just one area that teachers will be teaching and they cannot be a specialist in all subjects taught. They are less likely to have studied science to an advanced level in their own education.

Russell and Watt (1992) pointed that teacher's role in science teaching is to help children develop their understanding starting from ideas that they already have and teachers describe a range of methods that can be used to find out what children already know. As they add, teachers are expected to plan topics or areas of investigation around the development of understanding of key ideas and skills and to start a topic of investigation by giving children opportunities to explore and then express their ideas about their explorations. Teachers need to encourage children to discuss the reasons for holding their particular ideas and also help children to use one or more strategies to develop their ideas and to understand how they relate to the key ideas of the lesson. Finally, a science teacher needs to review with children the extent to which their ideas have developed and to plan further experiences to take the development further (Russell & Watt, 1992).

Previous Research on Children's Misconceptions

Eaton, Anderson and Smith (1984) aimed to find out if children's misconceptions interfere with science learning. The study was part of the Elementary Science Project, focused on the science teaching of 14 teachers and the data was collected through observations and audio-recorder lessons on the unit of light. Is worth mentioning that before the light and seeing unit was taught, children took a pre-test and after the unit they took the same test again, which was the basic source of information about children's conceptions. The results showed that students had difficulties in learning about light because neither their text nor their teachers adequately dealt with their misconceptions; "experiences and common sense can sometimes lead to inaccurate or incomplete conceptions that can prevent a student from learning" (Eaton, Anderson and Smith, 1984, p1).

Osborne and Cosgrove (1983) also investigated children's misconceptions specifically in relation to phenomena associated with the water and particularly children's conceptions of the changes of the state of water. A series of events involving ice melting, water boiling, evaporating, and condensing were shown to children in an individual interview situation. For each of the events, children were asked to describe and explain what was happening and explain what had happened. The analysis of the interviews showed that children bring to science lessons 'strongly held views' which relate to their experiences. These views appear as logical and sensible to them. Children have ideas about the changes of the state of water, but these ideas are quite different from the views of scientists and they can be influenced in unintended ways by science teaching (Osborne and Cosgrove, 1983).

Pine, Messer and John (2001) carried out research into teachers' view of children's misconceptions in primary science. Their analysis revealed that children have a lot of misconceptions about science topics and these misconceptions are of considerable importance and cannot be ignored in the learning process, since they are bases upon which knowledge in built. Teachers described a range of methods used to find out what children know but it was not clear if finding out what children know "involves searching for their correct notions about topics or actively probing for misconceptions" (Pine, Messer, John, 2001, p92). The results also indicated that teachers may think misconceptions get in the way of the teaching process, and are best ignored or squashed as quickly as possible. However, teachers need to place as much emphasis on children's incorrect ideas as on their correct ones if they want to accomplish conceptual change in science.

Some studies managed to design lists with children's misconceptions. The table below provides some usual misconceptions that children have about 'water cycle' as this is the target topic for this research.

Misconceptions in regard to:	
RAIN	**CLOUDS**
Rain comes from clouds sweating	Clouds come from somewhere above the sky
Rain comes from holes in clouds	Empty clouds are filled by the sea
Rain occurs because we need it	Clouds are formed by vapour from kettles
Rain falls from funnels in the clouds	Clouds are made of cotton, wool or smoke
Rain occurs when clouds get scrambled and melt	Clouds collide and split open and the rain falls
Rain occurs when clouds are shaken	Clouds get cold and then rain falls

In addition to the above we could also note that children may believe that when water evaporates, it just disappears and ceases to exist or that it immediately goes up to the clouds or into the sun. Finally some children find it difficult to accept the idea of invisible particles of water in the air (American Institute of Physics, 1998; M.D.E.S.S, 2005). Knowledge like the above can be more detailed for each topic that a teachers is planning to teach and it can help teachers to guide their students not just to construct new knowledge, but to construct it in the face of strongly held conceptions that guide their thinking and are incompatible with the new knowledge (Valanides, 2000b).

Research Questions

Children's misconceptions can be complicated and should not be ignored; they should be part of the content of teaching and as Valanides (2000b) declared, several teaching- learning problems can be overcome by students who are encouraged to be actively engaged in communication than from passive learners who just sit, listen and respond when the teacher calls upon them. But what does really happen in Cypriot pre-primary schools?

For this research the following questions were chosen: What do teachers know about young children's misconceptions in science? Do early years' teachers identify children's misconceptions and if so, how? How does this knowledge inform teaching? How do teachers respond and use children's misconceptions during the lesson? What kind of training do early years' teachers receive about children's misconceptions?

Methodology and the Research Design

The methodology was selected after careful consideration as it will define the process of collecting and analyzing data and information to answer the research questions (Hitchcock & Hughes, 1989). The selection of the methodology was based on the methods' appropriateness in relation to the research questions. A mixed methods research approach was used in this case indicating a research strategy that utilizes more than one type of research method which can be a mix of qualitative or a mix of quantitative research methods or a mix of both (Brannen, 2005). The fundamental principle of mixed methods research is that we can learn more about a topic when the strengths of qualitative research are combined with the strengths of quantitative research and at the same time the weaknesses of both methods are compensating (Johnson & Onwuegbuzie, 2004).

Specifically, this paper refers to a case study that will use unique examples of real people (teachers) in real situations; this will enable the understanding of Cypriot teacher's response to children's misconceptions in science more clearly. Indeed, a case study can enable the researcher to understand how ideas and abstract principles can fit together (Cohen, Manion & Morrison, 2000). As Bell (1999) noticed, case studies are particularly appropriate for individual researchers as they give an opportunity for one aspect of a problem to be studied in some depth within a limited time scale.

Specifically, this research design involved questionnaires, observations, interviews and focus groups and the research was constituted in three phases. The sample was randomly selected and it consisted of qualified teachers from all schools of south Cyprus working with three to six year old children. The aim of the first phase was to identify the characteristics of the population and was conducted last year. A questionnaire was sent out in order to determine the population's preferences when teaching science. This determined the key topic on which the research focused. The questionnaires were designed, piloted and sent to 75 schools in Cyprus that were randomly selected. According to Field (2009) the use of random selection increases external validity which refers to the degree to which the conclusions of this specific study would hold for other persons in other places and at other times. When the period of collecting the questionnaires ended, SPSS was used for the analysis which revealed the key topics that interest teachers. Based on these results it was decided that this research would focus on the topic 'Water- Earth-Space' as referred in the Cypriot Curriculum and specifically the 'Water Cycle'.

The first phase also included two key informant interviews of Cypriot university lecturers/ researchers that aimed to identify the current situation in Cyprus with regard to science teaching and specifically what student teachers are taught in regard to science and children's preconceptions. One of them was an experienced associate professor at university of Cyprus who taught 'natural sciences' to student teachers. The second one was an experienced teacher and college professor as well as he taught 'natural sciences' student teachers studying at private universities in Cyprus. These interviews assisted in understanding the participants' background and subject knowledge.

The second phase, which was conducted last year, included the lesson observations of six pre-primary teachers teaching the 'Water Cycle' in public classes consisting of children from three to six years old. The participants were selected in such way to cover all the main Cypriot cities. An observation schedule was designed to facilitate the observations, which was piloted during two other observations and the necessary changes were made before the actual observations took place. The observations lasted approximately fifty minutes. The lessons were designed by the teachers who were kindly asked to provide the researcher with the lesson planning. In some cases, some time was available after the lesson and the teachers allowed for some interaction between the children and the researcher. The observations provided the opportunity to approach teachers and children's world in order to understand their ways of thinking and acting during a science lesson and to compare what really happens in a classroom with what teachers say that happens. It also provided with precious data collected through children's work (like children's drawings).

Finally, the third and last phase was conducted this year. It included five interviews and two focus groups; these were held with the teachers that were observed and some additional teachers as well (total of eleven teachers). The aim of the interviews and the focus groups was to give the opportunity to teachers to express their beliefs and their opinions regarding science teaching, children's misconceptions, the conditions that they face when teaching science and also their ways of responding to children's misconceptions.

Preliminary Results

For the analysis of the quantitative data collected, SPSS was used and the analysis revealed that teachers consider 'Electricity' as a 'difficult' subject for children to understand and they do no tend to teach it. On the other hand, 'Plants and Animals' was defined as an 'easy' topic to teach and teachers tend to believe that children do not usually have misconceptions in regard to this topic. The topic that was selected to be the focus for this research was 'Weather-Water Cycle' because teachers described it as a topic that they usually teach and has 'medium difficulty'. Teachers also put this subject in the middle in relation to children's misconceptions which means that teachers believe that children have some misconceptions about this topic but now so many about 'Electricity' or so little about 'Plants and Animals'.

For the analysis of the qualitative data, collected through the observations, the interviews and the focus groups, NVivo software is being used. At a first stage of the analysis some tentative results will be presented though the analysis has not been fully completed. These initial results indicate that Cypriot teachers are not aware of children's misconceptions, especially the ones that have graduated from the Pedagogical Academy and have not participated in any seminars, conferences or other relevant science training. Also, a high percentage of in-practise teachers (seven out of eleven) do not usually attend any seminars or conferences about natural sciences because as some of them explained such seminars are not often and when they are such opportunities they have to sacrifice their personal-free time which is difficult as most of them have families and other responsibilities.

Additionally, only a low percentage of working pre-primary teachers in Cyprus has actually received any training at all about children's misconceptions. Actually only one of the participants of the interviews, the focus groups or the lesson observations, received any specific training about children's misconceptions during pre-service on in-service training. The specific participant is the one that graduated most recently and has only one year of teaching experience. This might indicate that training on children's misconceptions during the teacher qualification studies is rather rare or that is something that has only been recently introduced. As a result, most of the teachers said that they are not sure how they can respond to children's misconceptions and in some cases they did not even acknowledge their existence or their importance for the science teaching and children's learning.

On the other hand, those who graduated from the University of Cyprus could talk about children's misconceptions but they were not always able to describe how they can respond to them. They talked about methods that they use to identify the ideas that children have and they highlighted the importance of taking them into consideration when planning their science lessons. Based on the interviews and the lesson observations analysis we can say that the main strategies used by the teachers in order to teach the 'Water Cycle' were mainly storytelling through pictures and in some cases drama and experiment but not always with a clear pedagogic value for their use. Actually, five out of the six teachers that were observed had an activity at the beginning of the lesson which revealed some of the ideas that children had about the topic. Unfortunately, this knowledge was not used during the lesson by the teachers and a lot of times children's misconceptions were ignored by the teachers. In fact, only one out of the six teachers used ideas expressed by the children in order to build upon the lesson and accomplish the lesson's targets.

The following example shows a teacher apparently ignoring children's misconceptions. During the lesson the following comments were made by two children. When talking about 'Where rain comes from' a child said 'Clouds get angry and then we have rain' and another one said 'Clouds get grey when they are angry and then it rains'. This is an indication that the specific children might have a misconception in relation to clouds having human characteristics and this might affect his understanding of the 'Water Cycle'. At the end of the lesson, after a quick talk with the specific children somebody could realise that they continued to think that rain comes from angry clouds. Something like this would have been prevented in the teachers did not ignore the misconceptions expressed during the lesson.

It is worth mentioning that the analysis of the collected data has not been completed yet. Thus, further data analysis is necessary in order to provide more detailed results and identify how exactly teachers respond to children's misconceptions in Cyprus.

Conclusion

It is of great importance to investigate the area of children's misconceptions, since such knowledge can advice teachers and help them plan lessons to clear them up (Schmidt, 1995). Instruction which fails to identify children's misconceptions can leave children unchanged; whereas curriculum, instruction and assessment are significantly improved when teachers are aware of the development considerations and the research findings on commonly held misconceptions (M.D.E.S.S, 2005). The aim of this paper was to reveal the importance of taking into account children's misconceptions when teaching science. Something like this would assist in improving science teaching and learning in Cypriot classrooms. Nevertheless, more research needs to be done in order to be able to completely understand and evaluate the situation in regard to teachers' response to children's misconceptions in Cyprus.

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