‘Teachers and children’s misconceptions in science’

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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. However, 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. It 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:

<table>
<thead>
<tr>
<th>RAIN</th>
<th>CLOUDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rain comes from clouds sweating</td>
<td>Clouds come from somewhere above the sky</td>
</tr>
<tr>
<td>Rain comes from holes in clouds</td>
<td>Empty clouds are filled by the sea</td>
</tr>
<tr>
<td>Rain occurs because we need it</td>
<td>Clouds are formed by vapour from kettles</td>
</tr>
<tr>
<td>Rain falls from funnels in the clouds</td>
<td>Clouds are made of cotton, wool or smoke</td>
</tr>
<tr>
<td>Rain occurs when clouds get scrambled and melt</td>
<td>Clouds collide and split open and the rain falls</td>
</tr>
<tr>
<td>Rain occurs when clouds are shaken</td>
<td>Clouds get cold and then rain falls</td>
</tr>
</tbody>
</table>

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.

**References**


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