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*This is the second edition of the **Journal of Emergent Science (JES)*** to be free to all readers. Future editions will be available free to ASE and ESN network members and by subscription to others. For details of cost and subscription procedures please email Sharon Rolland at **sharonrolland@ase.org.uk**

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Editorial

Slowly but surely…or emergent science education is emerging

Coral Campbell

Welcome to this, the second edition of the ***Journal of Emergent Science (JES)**,* another useful issue highlighting some very interesting research and supplemented with short papers from this year's European Science Education Research Association (ESERA) Conference in Lyon, France.

At the 2009 ESERA Conference, a group of attendees formed a Significant Interest Group (SIG) in early childhood science, which was ratified by the ESERA Committee in 2010 (*see **Emergent Science Newsletter**, Nov 2010)*. At the recent Conference in Lyon, there was a significant increase in the number and type of papers submitted around topics of research into early years science education. In 2009, there were approximately 15 people who submitted papers in two sessions; this time, there were three sessions and 19 papers presented, as well as quite a few poster presentations. If the number of presentations at the Conference could be considered an indicator, it seems that early childhood science education is receiving more notice in the research community and is attracting more researchers to look at the depth and breadth of science education provision in early childhood.

In this edition of ***JES*** we have included the extended abstracts from two of the presentations delivered in Lyon. We hope to provide further examples in the next issue, so that you become familiar with the international researchers who are attempting to raise early childhood science education to the foreground through their research. The first paper, by Federico Corni, Enrico Giliberti and Cristina Mariani discusses a methodological framework for teachers that uses the way that children interact with materials and make sense from them as a method of teaching children the concept of energy. The second extended abstract (or short paper) is from Andrés Acher & María Arcà and describes a learning progression for teaching and learning about matter in early school years. These are just two examples of the many presentations provided at ESERA. As a taster, some of the other presentations included topics such as: the science professional learning of early childhood educators, fictional storybooks as science learning tools, instruments to monitor progress in emergent science, analysis of children's books, children's concepts of water, enquiry-based learning using story telling, implementing forensic science in early childhood science – and many more (see the ESERA website, **www.esera2011.fr/**).

I attended all the sessions and enjoyed the variety of research being undertaken and the robust discussions afterwards. I was particularly interested in the presentations around using 'fictional story' as a means of engaging with early years science education. One presentation used a narrative as a means of introducing children to the aspects of problem-solving and scientific processes. As the children read through the story, they would stop and undertake their own investigations around a problem raised in the story. Having solved that piece of the puzzle, they returned to the story and moved to the next problem. Another presentation used a discrepant event in the story to challenge children to realise the problem and discuss how the story might need to be changed to relate to scientific accuracy. This presentation raised some discussion around whether fiction should be allowed to remain just that, 'fiction', or whether an author has an obligation to be scientifically accurate. There was a general belief that, as imagination and fantasy were part of young children's lives, then non-accurate fiction had a strong place and function. This did not detract from the idea that story telling seemed to be an excellent way to involve children in learning science – it just depended on the choice of story.

Other papers within this edition include: an article on children's alternative conceptions, the use of drawings to elicit children's understanding of insects, and the skill of observation in young children. ***Children's Misconceptions and the Teaching of Early Years' Science: A case study**,* by Maria Kambouri, examines the idea that, if a teacher is aware of the alternative conception a child has, she may alter her teaching to accommodate that. The case study involved two kindergarten classes in Cyprus. Children were interviewed, pre- and post- a lesson on clouds. One class undertook their normal science lessons around clouds, whereas in the second classroom the teacher was made aware of the alternative conceptions the children had. To learn what happened in the two classrooms, you will need to read the rest of the paper!

Another article in this edition deals with the use of children's drawings to gain an understanding of their concepts of insects. ***Children's concept of insect by means of drawings in Brazil*** by Amauri Bartoszeck and colleagues highlights the importance of the skill of observation in young children. Most children use observation of insects and other small animals to varying levels, depending on their interests. This paper discusses the importance of observation for developing children's knowledge and understanding. The use of drawings as representations of children's understandings contributes to the developing field of representation in learning science and the way representational challenges can encourage greater depth of understanding around concepts in science. For further information around the way representations can be used in pre-school settings, see the article by Joshua Danish and David Phelps in the *International Journal of Science Education* (Vol. 33, no. 15, Oct 2011).

The third article, ***Young children as emergent biologists - Brine shrimps in the classroom*** by Sue Dale Tunnicliffe, discusses the analysis of children's spontaneous conversations around their observation of brine shrimps. Two groups were compared: children who were six years old and children aged ten. The analysis of the conversations provided a progression in observation from younger to older children. The paper highlights differences in what children of different ages actually observed and how they interpreted their observation. The author indicates that the *'questions raised by the children themselves are part of the developing ability to undertake inquiry through dialogic talk (Alexander, 2008), thus changing observations into inquiry.'* Conversation and dialogue with informed others is an important aspect of any learning and, in this situation, where children have questions they wish to find answers for, the teacher can use the opportunity to introduce children's own investigations.

So, whether you are a 'skimmer' and like to quickly review each article before choosing what to read, or whether you read from cover to cover in correct order, you will find this edition of ***JES*** has something for everyone. So, sit back and enjoy your reading!

References

Alexander, R. (2008) *Towards Dialogic Teaching: Rethinking Classroom Talk (4th Edition).* York: Dialogos

Coral Campbell, Guest Editor

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Contributing To The Journal of Emergent Science

The ***Journal of Emergent Science (JES)*** focuses on science (including health, technology and engineering) for young children from birth to 8 years of age.

The key features of the journal are that it:

- is child-centred;
- focuses on scientific development of children from birth to 8 years of age, considering the transitions from one stage to the next;
- contains easily accessible yet rigorous support for the development of professional skills;
- focuses on effective early years science practice and leadership;
- considers the implications of research into emergent science practice and provision;
- contains exemplars of good learning and development firmly based in good practice;
- supports analysis and evaluation of professional practice.

The Editorial Board of the journal is composed of **Association for Science Education (ASE)** members, including teachers and academics with national and international experience. Contributors should bear in mind that the readership is both national UK and international and also that they should consider the implications of their research on practice and provision in the early years.

The Editorial Board

Submitting to *JES*

Please send all submissions to: **janehanrott@ase.org.uk** in an electronic form.

Articles submitted to ***JES*** should not be under consideration by any other journal, or have been published elsewhere, although previously published research may be submitted having been rewritten to facilitate access by professionals in the early years and with clear implications of the research on policy, practice and provision.

Contributions can be of two main types; full length papers of up to 5,000 words in length and shorter reports of work in progress or completed research of up to 2,500 words. In addition, the journal will review books and resources on early years science.

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Contributing To The Journal of Emergent Science

Guidelines on written style

Contributions should be written in a clear, straightforward style, accessible to professionals and avoiding acronyms and technical jargon wherever possible and with no footnotes. The contributions should be presented as a word document (not a pdf) in Helvetica point 12 preferably with double spacing.

- The first page should include the name(s) of author(s), postal and e-mail address for contact.
- Page 2 should comprise of a 150-word abstract and up to five keywords.
- Names and affiliations should not be included on any page other than page 1 to facilitate anonymous refereeing.
- Tables, figures and artwork should be included in the text but should be clearly captioned/labelled/numbered.
- Illustrations should be clear, high-definition jpeg in format.
- UK and not USA spelling is used; i.e. colour not color, behaviour not behavior, programme not program, centre not center, analyse not analyze, etc.
- Single 'quotes' are used for quotations.
- Abbreviations and acronyms should be avoided. Where acronyms are used they should be spelled out the first time they are introduced in text or references. Thereafter, the acronym can be used if appropriate.
- Children's ages should be used and not only grades or years of schooling, to promote international understanding.
- References should be cited in the text first alphabetically, then by date, thus: (Vygotsky, 1962) and listed in alphabetical order in the reference section at the end of the paper. Authors should follow APA style (Author-date). If there are three, four or five authors the first name and *et al.* can be used. In the reference list, all references should be set out in alphabetical order.
- Web addresses should be checked at time of submission.

Guidance on referencing

Book
Piaget, J. (1929) *The Child's Conception of the World.* New York: Harcourt

Chapter in book
Piaget, J. (1976) 'Mastery Play'. In Bruner, J., Jolly, A., and Sylva, K. (Eds) *Play – Its role in Development and Evolution.* Middlesex: Penguin, 166–171

Journal article
Reiss, M. & Tunnicliffe, S.D. (2002) 'An International Study of Young People's Drawings of What is Inside Themselves', *Journal of Biological Education,* **36,** (2), 58–64

Reviewing procedures

Manuscripts are sent for blind peer-review to two members of the Editorial Board and/or guest reviewers. The review process generally requires three months. The receipt of submitted manuscripts will be acknowledged. Papers will then be passed onto one of the Editors, from whom a decision and reviewers' comments will be received when the peer-review has been completed.

Books for review should be addressed to Jane Hanrott, ASE, College Lane, Hatfield, Herts, AL10 9AA and should include full price and availability details.

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Children's misconceptions and the teaching of early years' science: a case study

Maria Kambouri
Supervised by Mary Briggs and Michael Cassidy

The aim of this paper is to examine how teachers' awareness of children's misconceptions can affect children's acquisition of scientific concepts. In other words, this paper is aimed at examining whether teaching is altered when teachers are aware of pupils' misconceptions of a specific science concept. This paper details a case study focused on two kindergarten classes of five year-old children and their teachers and took place in Cyprus. Two lessons were observed and three children from each class were interviewed. Through the analysis of children's responses it was possible to identify specific misconceptions related to the concept of rain. The results indicate that it is very important for teachers to be aware of what misconceptions children have, because this can help them plan lessons for children to overcome their misconceptions. It seems that it is more likely for children to overcome their misconceptions when teachers take these misconceptions into account as they plan and teach science lessons.

Keywords: early years, science, misconceptions, young children, teachers

1.0 Introduction

Young children enter formal education having their own understanding of the world, knowledge and scientific concepts, which will affect their school learning of science (Henriques, 2002). Some of these concepts are not always correct and can be extremely resistant to change (Black & Lucas, 1993). Children's conceptions that differ from those generally accepted by the scientific community are usually called 'misconceptions'. Ausubel (1968) was the first to use this term to refer to children's notions that are amazingly tenacious and resistant to extinction (cited in Driver & Easley, 1978). As a result, misconceptions can often pose strong barriers to understanding science and can be detrimental to learning (Clement, Brown & Zietsman, 1989).

Despite previous research, some might still argue that misconceptions can be the result of incorrect observations or illogical thoughts; they would also question the need to investigate them at all as they believe that they are wrong and, like the attention-seeking misbehaviour of a naughty child, can be best extinguished by lack of reinforcement. However, researching how teachers can help children alter their misconceptions is crucial for the learning to progress. This is because when teachers are aware of children's misconceptions they can use them for teaching and potentially rectify them (Schmidt, 1995).

The term 'misconception' is being used throughout this study to refer to *'children's ideas that differ from definitions and explanations accepted by scientists'*.

Even if this term carries a negative connotation with it, it is being used by many different authors and is easily recognisable. This is the reason that this term is being used for this study, as it is the most widely used one in the literature.

2.0 Theoretical background

In 1988, Treagust wrote that students' understanding of scientific phenomena had been of considerable interest to educational researchers and teachers of science. Eighteen years later, Chen, Kirkby and Morin (2006) were still highlighting that children's prior knowledge can greatly hinder their acquisition of new expertise. Children's misconceptions have been a main topic of discussion, for both teachers and researchers, for over two decades. This is why this study considers children's misconceptions as too important to be neglected and must be researched further, not just in Cyprus, but in other countries as well.

It would be a mistake to believe that five year-old children do not have any prior knowledge or misconceptions about science. According to Bradley (1996), all children have learnt some science before starting compulsory schooling, through their interactions in their everyday activities. He added that children will certainly have ideas about the world around them and how and why it works. The problem though is that children develop these ideas, which can then persist despite instruction. There are cases where 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', this might lead to making wrong connections (Driver, 1981).

The idea that children's learning is constructed and learners build new knowledge upon the foundation of previous learning leads to the notion of constructivism. According to constructivism, the learner is much more actively involved in a joint enterprise with the teacher and learning is not thought of 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 concepts and find solutions to problems.

Considering this, teachers should not assume or take for granted that all children have the same ideas. For example, research into children's ideas about the nature of light showed that teachers usually take for granted children's ideas in school science, and the only definition given is that light is '*a form of energy*' (Driver, Squires, Rushworth & Wood-Robinson, 2001). In contrast, 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 it produced*' (Driver *et al*, 2001, p.128).

In addition, an investigation into children's understanding of sources of light showed that children between 7 and 11 years old talk about primary sources almost four times more than they talk about secondary sources of light. The same research studied children's representations of light and 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 (*ibid,* 2001). The above research example suggests that children hold misconceptions that may affect their acquisition of new concepts in negative ways.

As a result, the ideas that children bring into science lessons need to be considered, as they are well established in their ways of thinking (Treagust, 1988). As Schmidt (1995) noted, leaving children to their misconceptions and hoping that they will overcome them on their own is unfair. Teachers need to take misconceptions into account when planning their lessons, but they seldom have the time to identify children's misconceptions and are often forced to assume a certain base level of students' knowledge (Chen *et al*, 2006).

It is quite worrying when teachers say that they do not have enough time, because teachers are the ones responsible for helping children to organise their knowledge and misconceptions into coherent concepts (Pine, Messer & John, 2001). Teachers describe a range of methods that can be used to find out what children already know, including discussions, brainstorming and predicting. Still, the results of this research indicated that these methods are not used often as, according to the teachers, misconceptions get in the way of the teaching process, but they can be ignored or squashed when possible (Pine *et al*, 2001).

Similarly, Osborne and Cosgrove's (1983) research revealed that children bring to science lessons strongly-held views that closely relate to their experiences; as a result, these views appear logical and sensible to the children as they try to make sense of the world around them. Researchers have also examined children's understanding of specific science concepts and have uncovered numerous misconceptions (Snyder & Sullivan, 1995). As an example, Bradley (1996) 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 tops of the clouds and pushes the rain out and it rains down to us*' (Bradley, 1996, p.3). Likewise, Worth (2000) discusses how children understand the concept of the earth being round and showed that children will say that the earth is round, but their image of *'round*' is the shape of a two-dimensional pancake rather than a three-dimensional sphere.

When trying to understand how children form misconceptions, Hanuscin (2007) pointed out that they can be formed in various ways and that they are often passed on by one person to the next. Snyder and Sullivan (1995) stated that children with misconceptions might convince others in a group to believe them. Worth added that children's early misconceptions arise from their own experiences (2000). Cohen and Kagan (1979) and, later, Hanuscin (2007) agreed that misconceptions can arise when two or more learned concepts get mixed up as children attempt to connect and organise their knowledge. Common words can also confuse children and create misconceptions, as they are used in everyday life but do not bear the same meaning when used in science (Hanuscin, 2007). This is due to verbal confusion and it is thought to be one of the most common ways to form a misconception, although misconceptions can arise from both verbal and conceptual confusion (Cohen & Kagan, 1979).

Unfortunately, there is no recipe for good early scientific learning. There are many important features of the early scientific learning process and each one is important in enriching learning. It is the interrelation of the different features that is important, rather than the individual features alone (Johnston & Gray, 1999). For example, teachers worry about *'not knowing enough',* because they believe that teaching means that they must have all the answers to children's questions (Russell & Watt, 1992). However, in practice, nobody could really answer all the questions that children might raise. In many cases, it would be wrong to answer them because giving children facts that do not link into their own experience and thinking can deter them from asking further questions, since they find that they cannot understand the answers (Russell & Watt, 1992).

According to Johnston and Gray (1999), learning is much more affective if the experiences are more practical. Children should be given opportunities to develop in each of the three areas of learning: cognate, conative and affective development. The more memorable an experience, the more likely it is to affect children's development and this is why early scientific experiences should be fun and child-centred learning experiences, which will take account of children's prior knowledge and misconceptions (Johnston & Gray, 1999).

3.0 The Cypriot context

It is worth mentioning that children's misconceptions are not addressed by Cypriot textbooks and traditional instruction, and teachers might not acknowledge that they can constitute a significant obstacle to learning (Valanides, 2000). According to the Cypriot National Curriculum (Ministry of Education in Cyprus (MoEC), 1996), Cypriot kindergarten teachers need to be generalists, as they have to teach all subjects. The Cypriot National Curriculum does not specify the contexts in which science concepts should be taught, so the decision is up to teachers (Bradley, 1996; MoEC, 1996).

Cypriot education considers science to be a main subject and it is identified as one of the core subjects to be taught in kindergarten (MoEC, 1996). A reference book is also available and, in that, teachers can find examples of activities and general suggestions of how specific scientific concepts can be taught, but it is up to each teacher to decide how to teach this subject (MoEC, 2004).

The Cypriot National Curriculum (1996) recognises that science lessons should be connected to children's everyday experiences in order to enable children to develop their scientific perceptions. Communication is considered to be an integral part of the science activities, as it helps children develop their skills of collecting and presenting information. These skills have to do with the careful observation, the linguistic expression and also the expression via drawings, simple graphic representations, models and dramatisations.

As a result, science learning in Cypriot classrooms is expected to include such activities as 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. Science learning is also expected to include activities that require children to make comparisons, find similarities and differences, make tests and experiments and export conclusions, which also help children develop scientific skills and have beneficial repercussions in the whole learning process (MoEC, 1996).

However, to be able to interpret the data collected, there are some characteristics in regard to the climate of the specific country and the possible experiences of rain that the children are likely to have. Cyprus has a subtropical climate – Mediterranean type – with very mild winters and warm to hot summers. Snow is possible only in 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 the rainy season for Cyprus. Thus, the context of the interviews and the lessons were not irrelevant with children's everyday experience at that period of time. The hot climate and the continuous drought of the last two years have presented Cyprus with a problem of water shortage, leading to a need to inform the public and ask for their collaboration. Media is used to inform the public and it is likely that children would have listened or heard something that informed them to some degree about the subject.

As a result, children living in Cyprus and especially those not living in areas close to the mountains will not have many experiences of rain and snow. This suggests that teachers need to find ways to offer as many experiences as possible to children in regard to this topic. In addition, prayer is routine for all classes and some teachers may use this time to pray with children to God asking Him to send rain to Cyprus. This can affect children's understanding of the conditions that are necessary for rain to fall and of the weather in general and might lead to several misconceptions.

4.0 Research questions

This case study aims to inform teachers about how important awareness of children's misconceptions is and their effect on children's learning. Teachers need to be motivated and dedicate time to finding out children's misconceptions and using them in their lessons. Hopefully, this case study will not only help early years teachers but, eventually, every science teacher, to realise the importance of acknowledging misconceptions in their lessons.

The main research question of this case study refers to the importance of considering children's misconceptions when teaching science. Specifically, the question is: *Are children able to overcome their misconceptions when their teachers are aware of those misconceptions?*

Specifically, the aim is to find out if children have more, less or the same possibility of overcoming their misconceptions when the teachers are aware of these misconceptions, with respect to the science subject they want to teach. We are also interested in finding out what ideas five year-olds usually express when they talk about 'rain'. Thus, the hypothesis is: 'When teachers are aware of children's misconceptions, there is a better possibility for children to overcome those misconceptions'.

5.0 Research methodology

This is a small-scale case study, which makes use of the experimental design. Sometimes, it is neither desirable nor ethical to use the experimental design, as it may keep the control group under strict procedural control, which can favour the results (Cohen, Manion & Morrison, 2003 & 2007). However, this was not an issue for this small case study, since the participants of the control group had their lesson in a normal format to reduce the possibility of affecting the participants' knowledge comprehension. In addition, the participants of the experimental group could perhaps benefit from the procedure, if the hypothesis proved to be correct.

The experimental design was selected after careful consideration and because it was found to be the most appropriate method to investigate if teachers' acknowledgment of children's misconceptions affects science teaching. To achieve that, observations along with interviews were used, in order to get a holistic idea and, at the same time, specific knowledge of how teachers' acknowledgment of children's misconceptions might affect science teaching and therefore assist children in overcoming their misconceptions.

Two pre-primary public schools were randomly selected in the area of Nicosia (the capital of Cyprus). Letters were sent to each school, explaining the study and kindly asking for their participation. Both Headteachers responded positively and, after talking with the appropriate teachers, they sent a note to all parents informing them about the study and asking permission for their children to participate. Of the children whose parents responded positively, three from each school were randomly selected and consulted about how comfortable they were with the proposal. The number of boys and girls that would participate was not an issue as gender was not one of the focuses of this study. The six[1] children that were chosen to participate were between four and five years old.

Both teachers were white females and the children attending the schools came from a wide range of socioeconomic backgrounds. One of the selected classrooms served as the control group and the teacher was left to teach without knowing children's misconceptions. She was specifically asked to teach the lesson as she always used to. The second classroom served as the experimental group. The teacher of this classroom was informed of the misconceptions that some of the children in her class had; then she was freely left to teach.

In an early years classroom, a range of events take place; for example, teachers and children pose questions, new concepts are explained, children experiment and talk to each other. For a study like this, it is important to have an insight into what is going on in a traditional Cypriot early years classroom. Therefore, the lessons related to 'rain' given by the two teachers were observed.

Interviews with the children were also used to collect data, as they are a usual means of obtaining information about children's conceptions (see Appendix 3). A number of direct questions to children about what they know is an obvious shortcut and these were very helpful in making a comparison of children's answers before and after the lessons (Schmidt, 1995; Treagust, 1988). After obtaining permission from the participants and their parents, the six children were interviewed and the conversations were audio-recorded. The interviews were semi-structured and each child had to answer the same questions, either in a different order or with additional questions, to probe their understanding or responses further. The audiotaped interviews help to protect the authenticity of the data and to avoid being inaccurate or incomplete (Robson, 2002).

The initial plan was to interview each child individually, so that children would not influence each other. Unfortunately, the Headteachers asked for all three children to be interviewed simultaneously because of time pressure. As a result, the interviews took place in groups instead of individually and this could put the results in question. At the beginning of the interview, all the children were assured that this was not a test and they were encouraged to express their own ideas without being influenced by the others. Specifically, they were told that there was no correct or wrong answer to any of the questions that would follow.

[1] The small number of teachers and children involved is due to lack of time and money. This small scale case study was meant to inform the context of a bigger study.

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For the timing of the interview, special consideration was given so that children would not miss activities that they enjoyed, including their playtimes. This was quite hard to accomplish for all the participants but, on the positive side, they seemed to enjoy the interviews, and they said that they were happy about helping out with this study.

When the interviews were completed, the teacher of the experimental group was informed of the answers given by the three children from her class and specifically the ones that indicated that the children had a misconception. The lessons related to 'rain' were then observed, in order to discover if the teacher of the experimental group would use her knowledge of children's misconceptions in her teaching. During the lesson, observation notes were taken in order to answer the following questions that had been set in advance:

- Is there a lesson planning – was the teacher well prepared for the lesson?
- Were the activities connected/ related?
- Were the children actively involved?
- Were there any activities that aimed to find out what the children already knew?
- Were there any activities that could show what the children had learned?

Both lessons lasted approximately thirty minutes. In both cases, one of the researchers joined the classroom; the teacher introduced her to the children and the researcher then sat at the back of the class. The lessons were recorded and, during the lessons, notes were taken that aimed to answer the above questions.

With the end of the lessons, the same children were interviewed again to find out whether or not they had overcome their previous misconceptions. The answers that the children gave during the first interview were compared with those of the second, and these, along with the notes, helped in exploring whether the lesson had helped the children to overcome their misconceptions and also if the lesson planned by the teacher was affected by the teacher's acknowledgement of the children's misconceptions.

6.0 Ethical considerations

As has already been said, to avoid exploitation of the children, permission for each child to participate was requested from the parents, as it would be almost impossible to inform young children fully about the study (Aubrey, David, Godfrey & Thompson, 2000). The best interest of each child was the primary consideration and children had the right to express their views freely, commensurate with their age and maturity. The study recognised that participants might experience stress or discomfort, hence the interviews were carried out in the schools' libraries, which were a friendly, comfortable and safe environment. Finally, children were informed of their right to withdraw at any time, for any or no reason (BERA, 2004).

Additionally, to avoid making teachers feel that they were being 'used' without their consent, both teachers were informed that they were part of an experiment, but that they could not be told all the details at that moment in case this affected the results. They were, however, presented with these details afterwards. It was also important to keep the participants and the schools anonymous. Thus, real names were never mentioned during the study and everything stayed unidentifiable as far as possible (BERA, 2004).

The aspiration of this study was not only to answer the research questions but also to make things better for the participants. The hope was that at least the children whose teacher was aware of their misconceptions would overcome those misconceptions. In no case would children be treated as if they were observable and measurable data gathering machines (Aubrey *et al*, 2000).

7.0 Analysis of the data & findings

In order to analyse the data collected, NVivo was used, which helped to organise the data and identify key words and themes. Specifically, the data collected before the lessons took place were compared with the data collected afterwards. Children's answers were compared through a '*before and after*' method in an attempt to identify the way in which these answers changed, and the possible connection that this had with the lessons that took place.

The data collected provided answers for all research questions. The analysis and categorisation of the children's answers provided a list of some misconceptions that the children mentioned. These were:

- The sun boils the sea to create water vapour.
- Clouds are formed by vapour from kettles.
- Clouds are made of cotton, wool, or smoke.
- Clouds travel from one country to another carrying with them rain.
- God makes rain and clouds.
- It rains because we wish or pray for rain.

The teacher of the experimental group was informed in advance about the misconceptions held by the children interviewed from her class. However, there was no discussion about these, to avoid influencing the teacher in any way. The lesson observation was planned for a specific day, but the teacher asked to reschedule the observations because she needed more time. This might suggest that the teacher, after reading the list with the children's misconceptions, felt that she needed to do something different, or be more prepared in order to help them overcome these misconceptions.

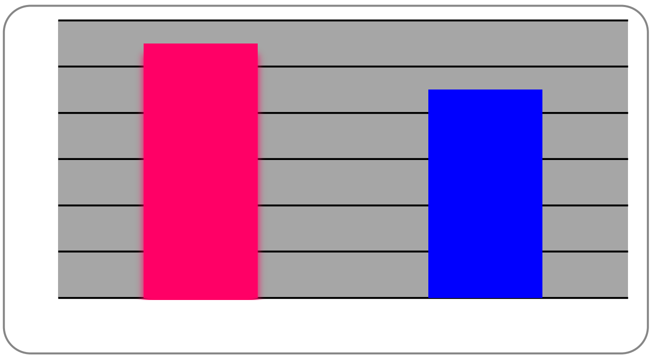
The lesson that this teacher planned was entitled: *'How does water become a cloud and then rain again?'* (see Appendix 1). The whole lesson was aimed at answering this question. Children discussed the question and tried to answer it. During the conversation, some interesting ideas emerged and they used words such as 'vapour', 'evaporation' and 'steam'. Finally, the class ended up with an 'answer'. The teacher suggested an experiment in order to check the validity of this idea. The lesson ended with the experiment and discussion.

The teacher was prepared for the lesson and there was a lesson plan. The activities were well organised and the lesson developed smoothly. The teacher gave children the opportunity to express their ideas and get involved. The lesson began with an activity during which children were asked to talk and express their ideas and this allowed the teacher to find out what children already knew. There was no final activity that could reveal what children had learned, or if they had overcome their misconceptions. The interview of the experimental group showed that this lesson really helped these children overcome their misconceptions. The answers that the children gave after the lesson were more specific and more correct, in contrast with the answers that they gave before the lesson. For example, during the first interview, a child's response to the question *'What is a cloud made of?'* was *'I don't know'*, whereas, during the second interview, the same child responded to the same question by saying '*A cloud is made of water'*. Another child responded to the same question with *'God takes water and puts it in clouds'* in the first interview and then replied *'Water becomes a cloud because in summer the water from the seas evaporates and becomes steam and then cloud'* during the second.

Similar improvements were also observed in other answers that the three children gave. The percentage of children's answers that showed improvement, for conceptual knowledge, was 55% (see Graph 1). Specifically, thirteen children's answers out of the total twenty-four indicated that the children had overcome their misconceptions, but this does not mean that these misconceptions were 100% overcome, or that the knowledge would be retained. In other words, 55% of the responses that the three children gave as part of the experimental group were closer to what is accepted by the scientific community.

This percentage is quite high and it cannot be due to changes in the children's maturity, as there were only a few days between the two interviews. It is more likely that the specific lesson effected the improvement in children's responses. With the completion of the lesson, the teacher was asked if she had considered the children's misconceptions when planning the lesson and she answered positively. This, together with the observation and configuration of the lesson and along with the fact that the teacher asked for more time because she was not feeling prepared, possibly demonstrates the importance for a teacher to be aware of pupils' misconceptions.

Graph 1: Percentages of the answers given by the children in the experimental group

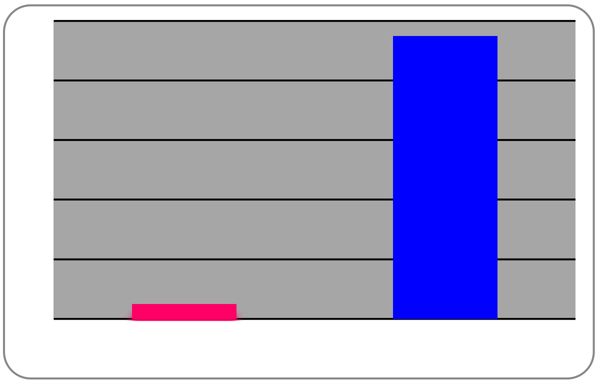


The control group teacher, for reasons not made clear, chose to base her lesson on a fairytale with the main topic being a newborn squirrel learning about the four seasons (see Appendix 2). Through this fairytale, the control group teacher talked with the children about clouds and rain and the lesson neither included an activity that would help the teacher check what pupils already knew, nor one that could show what pupils had learned. The whole lesson was based on storytelling and, most of the time, the children were seated on their chairs listening to the teacher, apart from when they had to answer quick questions. For example, the teacher asked: *'In summer, when the sun is shining and is very hot, what happens to water?'* and a child answered *'It goes high'*. The teacher added: *'I want you to tell me a word that means this'* and another child replied: *'It makes it cloud and steam'*. The teacher then said: *'It evaporates it.'*

In similar cases, some children had the chance to express their opinion about how water becomes a cloud or about what happens when it rains.

The interview of the control group suggested that this lesson did not help the children to learn or to overcome their misconceptions. The answers that the children gave before the lesson were more or less the same as those that they gave afterwards. This might suggest that the lesson did not improve children's understanding of the concept that the teacher wanted to teach. As we can see from Graph 2, only 5% of children's responses showed improvement.

Graph 2: Percentages of the answers given by the children in the control group



Such a low percentage could be due to the fact that this lesson did not include an experiment or active participation by the children. On the other hand, the fact that we have two different teachers with different classes of children each with different experiences might affect the results. Individual differences should always be considered when talking about educational research. However, the fact that the control group teacher was not aware of the children's misconceptions also played a crucial role in the results. The analysis of the interviews and the observations revealed that there is more potential for misconceptions to be overcome when teachers are aware of children's prior knowledge and misconceptions related to the subjects taught. It seems that, when teachers know what potential misconceptions children have, they tend to plan lessons with activities that help children overcome their misconceptions more effectively.

8.0 Conclusion

This is a small case study and the results are not to be generalised. Additionally, the fact that children were not interviewed individually could suggest that their responses were affected by the rest of the group. However, the results of this case study should not be ignored, as they tend to agree with results from similar studies. The important thing to note from this study is the benefit that children gain when time is dedicated by their teachers to establish what misconceptions the children have, as part of assessing their prior knowledge. This can help teachers plan more effective lessons to help children overcome their misconceptions. Children need to be encouraged to test their ideas and develop more specific definitions for particular words, so developing their scientific vocabulary. It is only through attention to children's misconceptions that effective science teaching can take place and children's learning in science can progress.

This case study only begins to scratch the surface of research work in this area for this specific age group and context. Although misconceptions in science have been researched internationally with different age groups, there is no specific evidence that teachers always acknowledge, identify and alter children's misconceptions to ensure the correct scientific learning takes place. In regard to Cyprus, as Valanides (2000) highlighted, a review of recent studies and reports on Cypriot education has shown that little is known and written about children's misconceptions and there is a need for more research into this area of investigation.

If this study was to be repeated, then a larger sample should be employed and individual interviews should replace group interviews. Additionally, the teachers that participate should have as much contact as possible with the researcher in order to get advice during the planning and the teaching of the lesson. This would allow the researcher to follow the teacher's thoughts on how the class would be deployed. Future research could also investigate misconceptions that children have with respect to more than one scientific concept. Finally, research that would identify methods that teachers could employ to find out what misconceptions young children have, and how they can help children to overcome them, would be useful.

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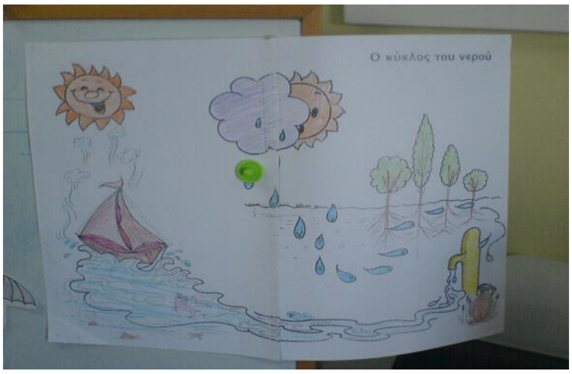
Appendix 1:

Observation of the lesson taught to the experimental group:

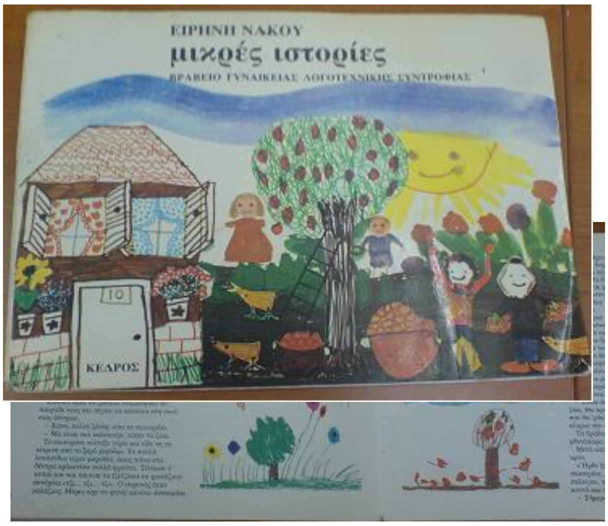
The photo shows the materials that the teacher of the experimental group used for the experiment. The experiment helped children understand how water becomes steam and cloud and then rain again by ‘seeing’ it happening. The teacher was boiling water in a bowl and at the same time was holding a cold plate over the bowl. The plate was cold as it was placed in the refrigerator before the experiment and, at the beginning of the experiment, all the children touched it in order to feel how cold it was. So the children saw the water becoming steam because of the heat from the fire, as the water on earth becomes steam because of the heat from the sun, and then they saw the steam touching the cold plate and becoming water again and falling like rain on the desk, as clouds become water when it is cold and then the rain begins. The experiment, in addition to the discussion, helped children to understand how water becomes a cloud and then rain and this was revealed from the interviews and the answers that the three children gave during the second interview.

The teacher of the experimental group also used this picture, which shows the ‘water cycle’, in order to provide children with an image of how water moves on earth, in an endless cycle. Children described this picture and discussed how water changes from liquid to solid and gas and about how it becomes rain and then cloud.



Appendix 2:

Observation of the lesson taught to the control group:



The first photo (above) shows the cover of the book that the teacher of the control group used in order to teach the concept of ‘rain’; the second (below) some inside pages and the third photo (below) shows the class alignment and how children were seated during the lesson.

Appendix 3:

Structure followed for Interviews:

For each question, some time was given to each child to observe the related picture.

Picture no 1 - questions:

1. Can you describe what this picture shows? (This question was only asked at the first interview).
2. Where does the rain come/fall from?
3. What is the rain?
4. Where does this water come from?
5. Why do you think that it rains?
6. Does it rain because we wish it to?
7. Does it rain because we are in need of water?

Picture no 2 - questions:

1. What is a cloud?
2. Where do clouds come from?
3. What is a cloud made of?
4. Is there anything inside a cloud? If yes, what is there inside a cloud?
5. How does water become a cloud? (if the child answered that a cloud is made of water or vapour.)

Pictures no 3, 4, 5 - questions:

1. Can you tell me what you see in these pictures?
2. How do you use water in your house?
3. Where do people find the water that they use for all these things that you said?
4. Did you learn something new today from the science lesson? (This question was only asked at the second interview.)

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Children's concept of insect by means of drawings in Brazil

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Bernadete Rocha da Silva
Sue Dale Tunnicliffe

Children have a basic similar knowledge of real insects and other invertebrates, which they assimilate from their spontaneous observations during their everyday life, in their gardens, the locality or in the school grounds. Fifty-three children aged 4, one hundred and thirty four children aged 5 and 29 children aged 6 enrolled in southern Brazil preschools were invited to participate in this exploratory study. They were asked, in their native language of Portuguese, to draw a representation of what the word 'insect' meant to them. Results show the importance of everyday observations beyond formal education for the developing knowledge of children. Children from the earliest years notice insects in their everyday lives and build a bank of knowledge, gradually acquiring an understanding of adaptation of habitats. Children notice insects in their lives to differing extents and sources according to the culture in which they are immersed. Experiences of seeing or finding out about insects are encapsulated for many children in the form of narratives and contribute to their mental models of insects and their habitats upon which they will draw in formal science later (biology and environmental education).

Keywords: children, insects, mental model, drawings

1.0 Introduction – Children in the natural world

Very young children, aged 4 to 6 years, notice and find out about living things around them. When children deal with living organisms, this offers countless opportunities for understanding the natural world and contributes to their science learning (Phenice & Griffore, 2003). Johnston (2005, 2010) highlights the importance of observation in the early years for emergent scientists. It is, she claims, *'arguably the most important skill in science and certainly the first skill we develop'* (Johnston, 2005, p.33). We know from research, e.g. Inagaki & Hatano, (2002), that all children entering school have a naive biology acquired intuitively from the world and people around them. Through urbanisation and a reduced freedom for children to play unsupervised, there has been a loss of opportunity for children to readily engage with natural objects and living things in their home environment. Children in many developed countries are acquiring a *'nature deficit'*, (Louv, 2006) and are increasingly out of touch with the immediate natural world. However, the concepts of animal and plant are fundamental ontological categories that allow children in every culture to organise the perception of the world in which they live (Angus, 1981). Thus, in the preschool stage, the conceptual learning of sciences by children aims to help to give a meaning to the natural world around them (Vieira *et al,* 1968).

2.0 Insects in environments

Insects are the largest class of invertebrates and hence of living organisms. Their class is formed by more than one million species known all over the world, and specialists from many science institutions consider that in excess of 20 million species have not been identified by entomologists (Borror *et al,* 1992). These organisms present various kinds of feeding behaviours and act at all levels of the feeding chain.

The reaction of many people to insects is emotive and influenced by feelings of affection for insects benign to humans, such as butterflies or ladybirds, but by feelings of fear and disgust about insects perceived as harmful, such as wasps. Certain groups of insects, such as cockroaches, are considered particularly repulsive but, on the other hand, cockroaches, together with mealworms and locusts, may be an ideal organism for hands-on activities in the classroom, provided that they are kept in safe conditions as advised by safety organisations, as they are easily kept and studied.

When young children notice and find out about living things, observing at first hand for themselves living organisms, such experiences offer countless opportunities for understanding the natural world. The children do attribute meaning to organisms (Dominguez & Trivelato, 2007). Such encounters, however, can contribute to fundamental science learning (Phenice & Griffore, 2003). Moreover, out of school experiences are an important source of science literacy (Braund & Reiss, 2004) and can be reinforced by a planned biological curriculum in formal education in the early years, as well as other opportunities planned by teachers for informal encounters with and observations of everyday insects in their region.

There is a scarcity of studies on the ideas of young children about living organisms throughout the world; the study presented here was conducted in a kindergarten with children aged 4 to 6 years old in Brazil. Dominguez and Trivelato, (2007) investigated, adopting Vygotsky's social constructivist theoretical perspective, by means of drawings and interviews, how the meaning-making process with reference to insects developed among these pre-school children.

In the English Foundation stage (3-5 years of age), the more representative studies are about animals (Tunnicliffe & Reiss, 1999a; Huxham *et al,* 2006). In Malta, knowledge of young children's understanding of the organisms in their everyday world is informed by a study about animals, (Tunnicliffe *et al,* 2008), as well as about plants (Gatt *et al,* 2007). Patrick and Tunnicliffe (2011) looked at young children's understanding of plants and animals in a small sample from each respective country. Shepardson (1997, 2002) and Barrow (2002) investigated the understanding of kindergarten and elementary school pupils in the USA about insect morphology, habits and life cycles by means of drawings and interviews. Alves and Campos (2005) had investigated the concept of insects in the first four grades of primary school (7 to 8 year-olds) in Brazil. These researchers adopted Ausubel's meaningful learning theoretical perspective, a process by means of which a new information interacts with a simple one previously existing in the cognitive mind structure of the subject, in a way through which this new information acquires meaning for the child (Ausubel *et al,* 1978), and their results, obtained from analysis of drawings and interviews, concurred with the perspective of Ausubel. Children's drawings represented the main morphology of the concept insect. The researchers (Alves & Campos, 2005) counted which type of insect was mentioned more often. They found that the knowledge of the children studied was limited.

When children in Brazil start to attend kindergarten classes at 4 years old, they have a basic understanding of what an insect is. Personal observations reveal that these children call any small invertebrate a bug, or even a minibeast, (*bichinho* in Portuguese), although they might have a general understanding of the human body (Bartoszeck, 2009). The aim of this study was to establish with what insects children are familiar, and which insects they notice in their everyday environment in one area of Brazil. Such knowledge could provide a relevant starting point to following formal elementary biological education in later years. Therefore, learning about insects endemic to the country in which pupils live is part of their learning about science in the everyday world.

3.0 Children and insects

As children in a society develop, they meet insects at home, see insects in their garden, during walks through the streets, visits to relatives on farms and when in parks and places in the city in which they live, as well as in books and in other media representations (Tunnicliffe *et al,* 2008). The kindergarten teacher will probably tell the pupils that a fly should be kept away from food, not only because its features are 'disgusting', but also because flies may contaminate food and spread disease.

Furthermore, children in Brazil are warned that the bite of a mosquito can transmit a disease (Dengue Fever) to people in many tropical and temperate parts of Brazil (personal observation). On the other hand, kindergarten teachers may also tell the child that, although the bee sting is painful, the bee also produces honey, which is sweet and is used as food by humans. The teaching of basic biological science and other sciences in kindergarten, in addition to learning the rudiments of reading and writing and hygienic care, is intended to help children begin to understand the natural world and how it changes. In following this dual aspect approach to organisms, that of being beneficial yet also harmful in relation to humans, teachers may point out that insects are part of the living world and have a key role in the world, by pollinating flowers, for example. Therefore, the contents of the pre-school class curriculum should try to offer hands-on opportunities to put children in contact with natural phenomena and observe that there are some relationships between all organisms, particularly insects (Danoff-Burg & Colker, 2002; Maragon, 2008). Moreover, children are acquiring biological awareness about the natural world at second hand, through illustrated insect books, other invertebrate books and the media, and not direct contact. However, images of insects conveyed by the media are not always portrayed with scientific accuracy. Furthermore, on many occasions, adults may transfer to children their own inaccurate understanding of what is an insect. Even so, children do encounter insects in their daily lives. Therefore, this exploratory study sought to find out the possible stages children follow to build up meaning about small organisms, particularly insects. Additionally, the researchers wanted to find which external morphology would be represented on the drawings of an insect, if anthropomorphic pictures would appear, which insects of the local fauna are mostly represented, and whether a distinction is made between an 'insect' and a 'non-insect'.

4.0 Drawings as a research instrument

The researchers decided to try to access such understanding about insects through analysing drawings made by children. Drawing is easier than writing for many children, particularly for the youngest. Furthermore, drawing may act as a mediator, permitting the expression of their mental model of an insect. According to Symington (1981), three stages are involved in the development of children's ability to produce pictures:

- Scribbling: an exercise for the child to gain facility with pencil or brush, with pictures bearing very little, if any, resemblance to the object.
- Symbolism: where the picture is used more as a symbol of the child's idea of the object than to show what it is really like.
- Visual realism: where the object and the picture bear a closer and more detailed resemblance.

These stages outlined above are derived from the work of Luquet (cited by Krampen, 1991) who proposed the following five phases in drawing development:

- Scribbling (typical at ages 2-3 years)
- Fortuitous realism (the discovery of similarities between certain features of scribbles and objects in reality that emerge at ages 3-4)
- Failed realism (synthetic incapacity), seen in drawings from children of 4-5 years of age)
- Intellectual realism (the child draws what is known about reality; this stage is generally from ages 5-8 years)
- Visual realism (in this stage the child draws what is visible only from a certain point of view in reality, i.e. a certain perspective. This occurs between ages 8-12)

5.0 Drawing analysis

Luquet's basic hypothesis is that, in the development of drawings executed by young children, there is a gradual tendency toward realism. Thus, the final aim of drawing would be a *'realistic translation of the visual properties of objects into graphics'* (Krampen, 1991: 38). According to Luquet, children do not directly transmit the characteristics of objects in drawings; that is, they do not simply copy them but, rather, put on paper the features of internal models of objects they observe (cited in Krampen, 1991: 38). As biology teachers know, children find it really difficult to observe and then draw what is seen by them, (Lakin & Tunnicliffe, 2010), but we seek to attempt to use drawings to identify the structure criteria that children know belong to insects, not their drawing ability.

Children's graphic activity has been studied from the perspective of development stages. Drawings require the activation of many cognitive processes that are under the control of development of the nervous system, particularly the ocular-motor functions (Tallandini & Valentini, 1990). Barrett and Light (1976) proposed three development stages in children's drawings: symbolic, intellectual realism and visual realism. Hayes and Symington (1988) were more concerned about the use of drawings in science lessons and proposed a similar classification related to the ability of children to produce drawings, albeit by stages, but as a product both of purpose and skill. The classification of the stages is:

- Scribbling, when a child is gaining a better grasp with, for instance, a pencil and draws pictures that have no resemblance to the object observed or thought out.
- Symbolism, when the drawing represents the child's idea of what really would be the object in question.

- Visual realism, where the object and its drawing reflect a closer resemblance.

However, these stages originated from previous careful observations by Luquet, (1927/1929). Accordingly, as the child draws, s/he is not completely inspired by the model of an object in front of her/him, but on the image in her/his mind at the moment that s/he draws; that is, her/his inner model of the object or scenery. Therefore, the drawing is, in a way, a representation that might reveal the contents of the child's mental image or model. Thus, in the development of children's drawings, there is a tendency to realism. The goal of drawings is to find the graphic language of a child, as s/he invents continuously what s/he wishes to represent – a constant exercise of representing reality. Children draw what they know according to internal models, which become increasingly more complex (Krampen, 1991).

The use of drawings as a research tool in education is discussed by, amongst others, Hayes and Symington (1988); Cox (2005); and MacPhail and Kinchin, (2004). Drawings allow spontaneous representations without objection from children who like drawing, as it may act as a mediator, permitting the expression of conscious and unconscious contents. Backett-Milburn and McKie, (1999) examined the relevance of drawings as a technique that enables children to communicate their thoughts. Furthermore, animals and plants are parts of the everyday environment, even in urban locations. We wondered whether children are out of touch with nature or not? Thus, we sought to find out what animals, particularly insects, children knew from everyday observations.

6.0 Research questions

This study aims to explore the following questions:

- How a sample from southern Brazilian preschool children aged 4 to 6 represents the external morphology of an insect by means of a drawing;
- Whether there is any difference by age, gender and understanding in how a representation of an insect is depicted according to a scale of levels achieved.
- Which kinds of insects are most represented in the drawings made by the children.
- Whether there are anthropomorphic features in the drawings.

7.0 Methodology

Rubric and grading drawings

The researchers contacted schools that had agreed to allow their pupils to participate in the study. The Headteachers of the schools concerned dealt with the ethical issues of parental consent and procedures. The fieldwork was carried out in the southern part of Brazil, in Curitiba, state of Paraná, in four Infancy Education Schools. Infant school no. 1, where children attended kindergarten I, II and III, are respectively aged 4, 5 and 6 years. It is a municipality-funded school; that is, a non-fee paying institution. Infant school no.2 is a religious philanthropic pre-school, with the same range of pupils´ ages. It is also non-fee paying. Infant school no. 3 is a private middle class school and infant school no. 4 is a low fee-paying school for the children whose parents are clerks in shops and shopping malls. Both the later schools cater for pupils of the same age range as do School no. 1.

Infant schools 1, 3 and 4 have small libraries with a few science books and other children´s books. Infant school 2 has no library. Only school 4 has a back yard, with a few fruit trees and an orchard where pupils, with the help of teachers, plant vegetables that are eaten during snack time. None of them have a pre-elementary science laboratory, but do have overhead projectors, television sets, and VCR and DVD equipment.

Pupils aged 4, (53), 5 (134), and 6 (29) in southern Brazil participated in this study. Pupils were asked by one of the researchers to draw on a blank A4 sheet of paper what they think an insect is, or what they think of when someone says to them 'insect'. The researcher asked the question: *'Please draw for me on the sheet of paper an insect that you have seen and/or what "insect" means to you'* (Stein *et al,* 2001). The drawings were executed in a larger classroom than the student's normal one, where each second desk was left unoccupied in order to avoid, as far as possible, children copying from each other. Children were asked to draw in silence. Those pupils who knew how to write their names and ages were asked do so at the top of the page or, otherwise, the auxiliary teacher wrote for them. The drawings were collected during a regular period of the class and children were given about 15 minutes to finish the task. The drawings were collected and set apart for analysis.

The children who drew had previously, as part of the kindergarten curriculum, been exposed to occasional observation of ants running on the ground of the school yard and butterflies flying and visiting flowers in the school garden or at home. Class activities include insects as characters in book stories, as well as using colouring insect books, in which the child is supposed to colour in an outline of an insect.

8.0 Results

The salient features of an insect, according to a zoologist, would be:

- 3 pairs of legs used for walking but sometimes adapted for jumping;
- 3 parts to the body: head, thorax and abdomen;
- Exoskeleton characteristic of invertebrates;
- Anus at the end of abdomen (no post-anal tail as in chordates);
- Compound eyes;
- 2 pairs of wings (attached to thorax);
- A pair of antennae on the head;
- Complete (incomplete) metamorphosis (egg/larvae/(nympha)/pupae/imago); and
- The need for food, air, and moisture to live.

From our teaching experience, we know that, when children draw what an insect is, many children will place the insect's legs at the abdomen. Children may be associating, by analogy, this placing to that of human beings where legs are at the bottom of our bodies. In fact, an insect's legs are attached at its thorax. Moreover, children usually use the term 'bug' to describe any creeping, crawling invertebrate they encounter and, for this reason, they sometimes, for example, consider a spider to be an insect. A total of 215 drawings were collected (Table 1).

Table 1: Participants in the study (southern pre-schools), classified by age group, gender and numbers.

Age group	Male	Female	n
4 year-olds	25	28	53
5 year-olds	68	65	133
6 year-olds	13	16	29
Total	107	110	215

The researchers developed a rubric according to zoological criteria. Attributes recognised as those of insects for analysing the drawings were formulated by the authors (zoologists). The following criteria were used:

- Were the drawings recognisable as those of an insect; and
- Which features were portrayed? (The salient features drawn that the children found seminal were mainly wings, antennae, legs and body, which was sometimes elongated (see Figures 3, 4 and 5).

The drawings were examined carefully and scored by the raters, taking as a guide the scale of levels described in Table 2. Scoring of the drawings to evaluate the different levels of the salient features of an insect attained by these pupils' samples was carried out independently by the first two authors, with comments from the third.

Table 2: The rubric used for allocating a grade to the drawings

Level	Insect characteristics
0	Nothing
1	Scribble I
2	Scribble II with resemblance to body and appendages
3	Has resemblance to an organism with legs and/or antennae
4	Has resemblance to a caterpillar (head/body/appendages)
5	Single body, wings representation, often as a single structure with 2 lobes and/or antennae.
6	3 parts of body and/or antennae or wings.
7	6 legs and wings or antennae.
8	3 parts body, 6 legs on thorax, 1 or 2 pairs of wings, antennae.

The youngest children drew fewer insect species and some children drew scribbles resembling organisms, or just a scribble. A few children reproduced human faces on their specimens.

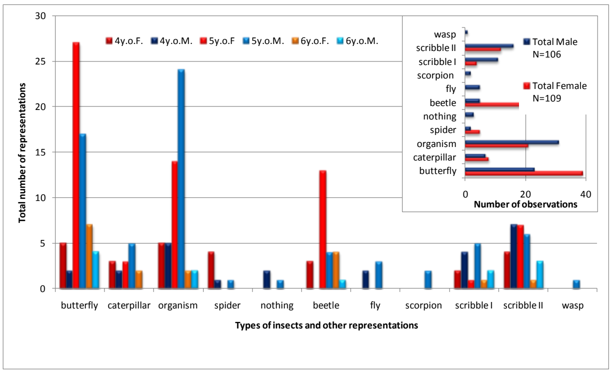

Figure 1: Most commonly recognisable drawings of insects (and other minibeasts) by age and gender.

Children drew spontaneously a few recognisable insects. The most drawn were butterfly, caterpillar (same type, different stage in life history), beetle, ant, bee imago (one each for bee and ant). They were evaluated according to levels of complexity as stated in Table 2.

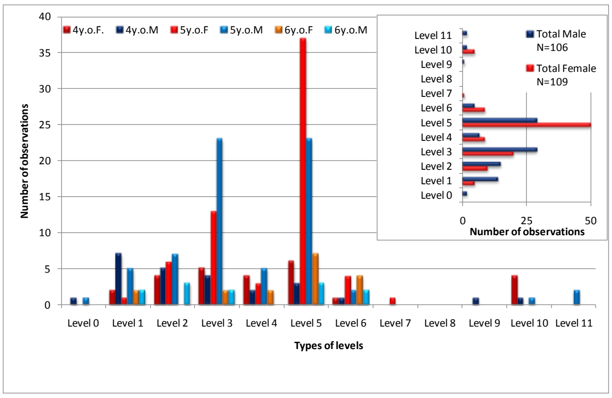

Figure 2: Drawing showing grade levels of insect (and minibeasts) characteristics (L.9, 10, 11).

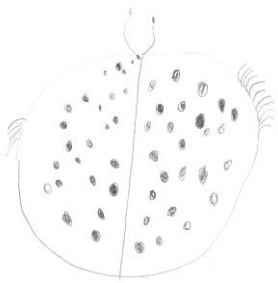

Figure 3: A drawing by a 4 year-old girl, which scored a level 6 according to grades in Table 2.

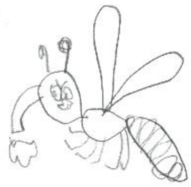

Figure 4: A drawing by a 5 year-old boy, which scored a level 7 according to grades in Table 2.

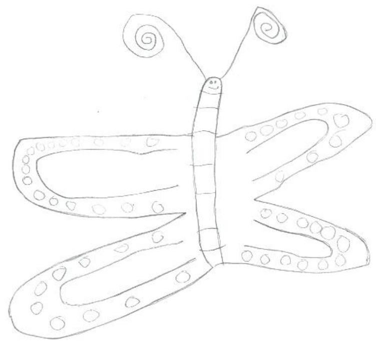

Figure 5: A drawing by a 6 year-old boy, which scored as level 5 according to grades in Table 2.

On inspection, the drawings in this sample from these 4-6 year-old Brazilian children revealed the same difficulties as were identified in other studies in the USA. For instance, Shepardson (2002) noticed that, from his sample of 20 kindergarten children, they identified spider (35%), bugs (33%), centipede (8%) as insects, and only butterfly (8%) and ant (2%) from the common organisms drawn. Barrow (2002) interviewed 4 children (kindergarten stage) about their understanding of insect characteristics, and these pupils just said that insects have 2 pairs of wings attached to the thorax.

9.0 Conclusions

In the conceptual learning of pre-school science, pupils seek to understand the natural world around them. However, this exploratory study highlighted that the understanding of what is an insect is mainly contextual and a few children take spiders and scorpions to be insects. However, the results are a reflection of the first steps to scientific development and a starting point to emergent science (Johnston, 2010) for these young Brazilian children. Children build up a model of insects, starting with the largest and most obvious parts of the insect that they notice, i.e. legs, body and wings, where relevant. The body is viewed as a whole in the first instance and the point of attachment for all appendages.

The results obtained from this sample of young Brazilian children resemble data obtained by Shepardson (2002) and Barrow (2002) from similarly aged American pupils, indicating a universal development of the concept of insect.

Insects most mentioned in the present comparative study were butterfly, beetle, ant and bee (the last two not included in Figure 1). Drawings showing a general insect pattern, sometimes with many legs, antennae and wings, were similar to those found by the above authors. We used drawings as a research instrument to probe the mental model children might have of what an insect is, which is not exactly the same approach as Sjoberg (2000) adopted in his study of the 'image of the scientist'. Work in progress, *'The perception of Brazilian adolescents of the image of the scientists'*, analysing 432 drawings collected, finds that it is rare to have a caricature of an insect similar to that of a depiction of a 'mad scientist' (Bartoszeck, 2011).

The pre-school (kindergarten) range of children´s ages is facing a change in Brazil. The new framework for kindergarten is to be restricted to children aged 3, 4, and 5. Thus, our sample of 6 year-olds was not equivalent to the other ages, as these pupils are progressively being enrolled in the 1st grade of primary school.

Although these Brazilian children had a limited knowledge of insects, they were able to identify non-urban insects such as the wasp. A few scribbles resembled an organism that we presumed was a tentative action to draw an insect. Perhaps this knowledge is contextual and children hold this knowledge because they live in an urban area and have vivid experience of direct observation in real life of certain exemplars of insects, such as flies and wasps, which might be more often expressed than other species that may be identified from a sample of children from sub-urban or rural areas, who are familiar with a wider range of types. A broader project is being planned with researchers from Portugal, Finland and Perú (Perú´s Amazonia). The authors are working to obtain funding for this project.

10.0 Educational implications

However, there are a certain number of books published for children about insects that could, in part, motivate children to know more about live insects. Unfortunately, funding for new and specific books is limited, particularly in public schools in Brazil. Also, parents are concerned when their children go out on field trips because of security reasons, such as the increase in crime and the lack of security due to the zoos and parks being outside the cities. The buses used to transport the groups carry only the teacher and driver, with no other adults to accompany the groups. This leads to parents discouraging the taking out of children from the immediate school environs. However, it should be pointed out that studies can be carried out in the immediate vicinity of the school.

During kindergarten teacher training, hands-on practice with insects is seldom carried out, except for the study of the complete metamorphosis of the butterfly in some undergraduate courses of education. However, there are some efforts to emphasise the need to introduce science during all grades of pre-school (Peixoto, 2010). In conclusion, insects can be used with great advantage compared to classroom or laboratory animals, as a teaching tool in all levels of science education (Matthews *et al,* 1997; Tunnicliffe & Reiss, 1999b; the University of Arizona, 2010). They are small, more easily cared for and readily available. Additionally, learning about insects endemic to the country where pupils live is part of their learning about science in the everyday world, and citizenship education, which is increasingly the emphasis given in the curricula of many countries. Above all, learning about other living things is part of a child's educational entitlement.

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Young children as emergent biologists – brine shrimps in the classroom

Sue Dale Tunnicliffe

Observation is a key part of effective learning of science, particularly biology. It is crucial for children to observe living animals as part of investigating using their senses. Analysis of spontaneous conversations generated during open-ended observations of brine shrimps reveal observations and interpretations in the early years and thus provide baseline data to compare with what older pupils observe, and their interpretations of the same new experience. Children aged 6 and 10 were invited, in small groups, to observe and talk about brine shrimps in bottle ecosystems. The conversations were recorded, transcribed and analysed for content. Statistical differences between the groups were identified, so that progression in observation from the emergent science stage of early years could be identified. Older pupils observed and commented more on behaviour, mating and identity of the animals than did the younger pupils.

Keywords: animals, classroom, conversations, observations, brine shrimps

1.0 Introduction

The early years, which lie in the Foundation Stage of education (3-5 years) and the first stage of the English National Curriculum at Key Stage 1 (5-7 years), are key in the education of children. The Early Years framework for children in school has four strands: healthy living, independence and interdependence, communication, and exploration, and these permeate through all the learning experiences planned and followed by children in 6 areas of activity:

- personal, social and emotional development;
- communication, language and literacy;
- mathematical development; problem solving, reasoning and numeracy;
- physical development;
- creative development; and
- knowledge and understanding of the world (embraces science) (DCSF, 2008).

At the early years stage, opportunities need to be planned in which children are given chances to encounter living things in their natural environment as they develop *crucial knowledge, skills and understanding of the world*. Such opportunities will also embrace aspects of the other activity areas, such as communicating and listening to the comments of others. Communication is of particular importance for the learning of science.

Early explorations in zoology occur from when a child is born and develop as they observe the world around them. Children gradually learn that animals differ in form; for example, a toddler learning to talk and in the labelling stage (Bruner, 1964) refers to every four-legged animal they meet as 'dog' if that is the kind they first saw. Gradually, with experience, of which observations are an important element, they learn that there are different kinds of dogs. Different kinds of animals are recognised and also the differences in the stages in the life cycle of some animals, such as tadpoles and adult frogs; larvae, such as caterpillars and their adult form of butterfly or moth. Moreover, children use themselves as their template by which to interpret living things and make anthropomorphic interpretations of form and functions (Carey, 1985). Learning science builds on what they have learnt before, so it is important to provide as many experiences as possible in the early years.

Johnston (2005) also highlights the importance of observation in the early years for emergent scientists. It is, she claims, *'arguably the most important skill in science and certainly the first skill we develop'*, (*Ibid,* p.33). We know from research, e.g. Inagaki and Hatano (2002), that all children entering school have a naive biology acquired intuitively from the world and people around them. Through urbanisation and a reduced freedom for children to play unsupervised, there has been a loss of opportunity for children to readily engage with natural objects and living things in their home environment (Louv, 2006). Louv further points out that fewer and fewer children experience the extensive natural world in our technological societies, as they live in a 'constructed environment'.

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In this electronic age, educators need to seek ways to bring children into contact with more living organisms.

Visits to primary schools today also reveal fewer animals in classrooms and laboratories in school. This decrease in living things has been noticed by other teachers and researchers, e.g. Reiss (1996). Some local authorities have health and safety rules particularly because of the increase in asthma and other allergic disorders. Also, the welfare of animals at weekends and in the holidays can be an issue. The attitude of pupils themselves to the sight of animals in lessons and the numbers of non-biologists now teaching science are possible factors affecting the lack of animals in classroom (Reiss and Beanery, 1992). Such attitudes, such as concerns about animal welfare and conforming to local health and safety guidelines interpretation, together with lack of confidence in teaching such biological topics, are even more prevalent in primary schools. However, part of children's science education entitlement is to have the opportunities to observe living animals at first hand.

There are universal aspects of the understanding of children about animals, in what is described by Atran and Medin (2008, p.137) as 'folk biological cognition'. Such cognition is based on what children see and learn from their everyday environment (Tomkins & Tunnicliffe, 2000). Although many people in England inhabit an urban world, children can notice the many living things that exist even in urban environments (Tunnicliffe, 2010a). Children's responses and comments about animals presented as exhibits in museums (e.g. Tunnicliffe, 1996), and their responses and knowledge about preserved or fresh dead specimens that have been shown to them in school (Tunnicliffe & Reiss, 1999a), have formed the basis of various documents. However, there is little work on the responses of young children to familiar living animals or to species that they have not previously encountered. Introducing an unfamiliar species to young children provides an excellent opportunity for learning through observation of such organisms, revealed through dialogue when watched in groups. Studies analysing the spontaneous spoken reactions of children observing live organisms in places such as zoos or field centres reveal that children notice and identify striking features of the anatomy and behaviour of animals (Tunnicliffe, 1996). Such experience and knowledge is not necessarily gained from formal education (Tunnicliffe & Reiss, 1999c).

When young children come across an unknown object, they talk about it. Their words express their mental model. Sometimes, the model is expressed in another mode, such as a drawing that can be seen by anyone (Buckley *et al,* 1997). The only way for a researcher to understand someone's mental model of a particular phenomenon is by considering one or more of their *expressed* models of that phenomenon. Spontaneous comments and conversations between children looking at biological specimens reveal their mental model of the new organisms interpreted through their understanding of experience and how they match this to the phenomenon that they are observing. Thus, the words of the children, if analysed, can reveal to teachers what the children know of the structure and behaviour of an animal and why it behaves as it does (Tunnicliffe & Reiss, 1999b). The key skill is observation, which is a universal activity, not only an activity of science. This basic skill is often taken as a 'given' in classrooms, but it is more than 'just looking' and is a key aspect of early years activities, especially in the area of knowledge and understanding of the world.

Children need to be taught observational skills, to frame and focus, to look with meaning and to record what they see, not what they think their existing mental model should reveal (Tunnicliffe & Litson, 2002). If children are given the opportunity to look in this way and make their own observations without a set task, they begin to act like scientists, to raise questions, hypothesise and make observations to help them answer their questions (Tomkins & Tunnicliffe, 2001). Brine shrimps are ideal animals to have in early years classrooms, to allow the children to observe and to generate scientific thinking.

2.0 Children's spontaneous observations – do they change in content and complexity?

We need research to learn how biological concepts and models develop and how those of the same phenomenon may develop with the age of the child. This article describes the use of brine shrimps to determine the development of observation in early years children and a post-emergent group, aged 10 years.

Figure 1: Drawing enlarged x 5 of brine shrimps in their characteristic swimming position. *(Drawing courtesy of S.P.Tomkins from the Brine Shrimp Ecology book from the British Ecological Society website)*

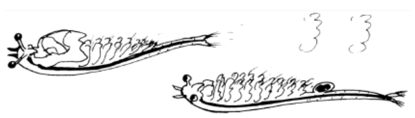

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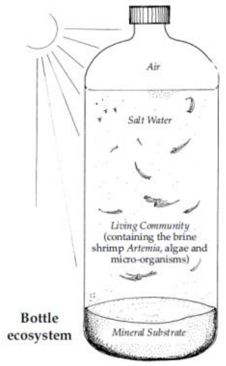
Figure 2: Drawing of a brine shrimp bottle ecosystem. *(Drawing courtesy of S.P. Tomkins from the Brine Shrimp Ecology book)*



Brine shrimps are invertebrate crustaceans, which can be kept in a bottle ecosystem that is closed – but the ecosystem needs warmth and light. If brine shrimps are kept in summer, the sun will provide the heat and light that they need. They are almost costless to manage and easy to watch and handle. They are disease-free and useful for teaching real biology. Children can easily take them home to observe.

The aim of the study is to capture and analyse the spontaneous talk generated by children aged 6 and 10 years as they look at an unfamiliar animal in a classroom, in order to ascertain what they notice and interpret. An incremental development of biological understanding of biological features from that shown at the end of the early years phase to that shown by pupils four years older may be found. This enables an understanding of the stage of development at the end of the emergent science stage and how it can be built upon.

3.0 Method

Bottle ecosystems of brine shrimps were taken into two classrooms in a Church of England primary school, one with Key Stage 1 Year 2 (age 6) pupils and the other with Key Stage 2 Year 5 (age 10) pupils. The likely response of the children to these animals was unknown. The research objective was to ascertain what the responses were in terms of scientific observations and interpretation, and also to establish if there were any affective responses and whether the responses revealed any understanding of the reasons for behaviour such as mating.

The necessary permissions were obtained from the Headteacher. The researcher had been CRB-checked as is required in England for people working with children. Observation of the brine shrimps and the recording of conversations were conducted with one group at a time over a number of days in a separate classroom. The class teacher selected groups of six pupils. Their entire dialogue was recorded, transcribed and analysed using a systemic network in the manner of Tunnicliffe (1996). Effectively, this is a counting process, with each category given a name once identified after re-reading the transcript until categories emerged. Then, on a hard copy, the words and phrases coded were counted for each conversation and a tally kept. The categories used were, firstly, management and social comments; secondly, the drawing of others to something, an ostensive or 'pointing out' comment; and thirdly, other features of the ecosystem, such as the gravel, the water, algae on the sides of the bottle**.** Other categories were: emotions or affective attitudes, interpretive comments that posed questions or gave information, and the last was comments about the natural environment (shown in Table 1 overleaf).

The category of animal observations was divided into three: *body parts, behaviour* and *naming*. Each of these super-ordinate categories were subdivided:

- *Body parts* into: front end observations (head, eyes); the size, shape or colour of the animals; unfamiliar parts, such as the claspers, which are not seen in everyday animals; and a category for other parts.
- *Behaviours* into: the position of the animals in the bottle; the movement; and food-related comments.
- *Names* had four categories into which children's comments could be allocated: everyday names, such as sea monkeys (a common name for brine shrimps); super-ordinate everyday category words, in this case, fish; a comparison with another organism; and, lastly, a mistaken identity (see Table 2 overleaf).

4.0 Results

The children made observations and interpreted them, sharing comments and interpretations. Pupils explained what they saw in terms of their own experience. The observations of Year 2 and Year 5 pupils were similar, although there were a greater number made by the older children. The comments were rich in metaphors, drawing upon the children's previous experiences and knowledge.

The pupils focused their conversations on the live animals, but they also organised each other and issued instructions as well as wondering and raising questions. A summary of the main categories of conversations for the two age groups is given in Tables 1 and 2. These categories are relevant to the process of science inquiry as well as the identification of animals. These data suggest that the younger children look and talk about some of what they see, whereas the older pupils are more discriminating and make more comments about certain aspects of the animals. The older children commented significantly more about aspects of anatomy – the size, shape, colour and behaviour of the animals, particularly fighting and mating (called attractor behaviour) and named the animals more than the younger children.

Table 1: Overall comments about brine shrimps from 6 year-old and 10 year-old children

Table 1	**Age group 1** 6 yrs N=109 %	**Age group 2** 10 yrs n=171 %	**Probability** Chi^2 degree
Category			
Management social	53	59	0.60
Drawing attention to the animals, etc.	25	35	3.31
Other features, e.g. water, gravel	31	36	0.60
Animal comments			
Body parts	76	83	1.66
Behaviour	55	71	7.19 ($P<0.01$)
Names	26	26	0.01
Other categories			
Affective attitudes	39	36	0.05
Interpretive asking questions/ giving information	92	88	0.85
Environment	0	4	N/A

Groups were formed by the children, of either single or mixed genders.

Table 2: Observations about the biology of brine shrimps made by 6 year-old and 10 year-old children

	6 yrs %	**10 yrs %**	**Chi^2 1df**	**Probability**
Animal obs.				
Body parts	76	83	1.66	
Front end – head, etc.	23	18	0.96	
Size shape and colour	58	70	44.07	$P<0.005$
Unfamiliar parts, e.g. claspers	24	16	2.82	
Other parts	11	13	0.22	
Behaviour	55	71	7.19	$P<0.01$
Position in bottle	36	31	0.69	
Movement	36	43	1.33	
Food-related	3	4	N/A	
Attractors, e.g. mating, fighting	15	37	16.14	$P<0.005$
Names	26	26	0.01	
Identity, e.g. tadpole, sea monkey	13	24	5.23	$P<0.025$
Category, e.g. fish	19	20	0.02	
Compare with another organism	17	19	0.07	
Mistake	2	1	N/A	

The emergent scientists started conversations with orientation comments showing the children's skill in communication, respect for other people's comments and bringing personal experience to their interpretation, as well as expressing some emotions! These six year-old children made the following remarks:

Girl 1 'Urgh!'
Girl 2 'I've eaten shrimps before but they were a bit bigger. Say what you think!'
Girl 1 'Urgh!'
Girl 2 'That's it!'

After this orientation phase, groups usually settled to make sense of what they were looking at through observing, thus developing their knowledge and understanding of an unfamiliar animal. The following group of 6 year-old girls showed some creative inclination, because they drew their interpretation of what they saw without being asked to so do:

Girl 1 'Look…it…over there how it swims or something'
Girl 2 'Yes over there'
Girl 1 'It's got black eyes and a black thing down its back, it's got sort of hairs on its back'

The following conversation from a mixed group of 6 year-old children shows that at least one of the pupils had some knowledge of the mating process and its characteristics, revealing some knowledge and understanding of the world.

Boy 1 'Two of them are sticking together'
Girl 1 'That's because they are mating Tim'
Boy 2 'They are not!!!' (Laughter)
Boy 1 'Look! There!'

One of the boys in this group went on to inform his peers that that is what you had to do when you fancied a woman – grab her before someone else could – an interesting insight into his knowledge. Such comments show that working with some organisms, particularly brine shrimps, does provide first hand situations related to personal and social education that teachers can develop later in 'circle time' or other appropriate moments (Tunnicliffe & Reiss, 1999).

Numeracy skills of a basic nature, but appropriate for emergent scientists, were heard from children watching brine shrimps. Some groups spontaneously counted the number of organisms in their ecosystem, showing the intuitive approach to data collection inherent in young children. They acted as intuitive emergent scientists who observe and collect data and statistics (Gopnik, 2009). This phenomenon is illustrated by the following dialogue from a group of 6 year-old boys, who observed and recorded the number they saw and compared the mode of movement with one they know. The following conversation shows how children will easily use their numeracy skills in data collection without prompting, if they have the chance, as well as interpreting using what they already know.

Boy 1 'There's some down there together,'
Boy 2 'They are like twins' (laughs)
Boy 1 'There's one up there!'
Boy 2 'Oh! There's three four, two there, two there'
Boy 1 'Brilliant! I've got 2 over here that don't really want to move. They are trying to move and they can't!'
Boy 2 'It's almost as if their wings were flapping but they flap in water not air!'
Boy 1 'Water wings!'

The study shows that, whilst there was similarity in conversational content, there was also progression in complexity. Older children make more complex observations, but about similar things. A group of 10 year-old girls interpreted the black 'dots' in the bodies of some of the brine shrimps as eggs, showing an understanding of egg production and the differing roles of the sexes. They interpreted the smaller shrimps as young ones, revealing that they had an understanding of change of size in the development of organisms that did not display complete metamorphosis.

Girl 1 'There are eggs on this one'
Girl 2 'Here, there's an egg falling.' (bits of substrate)
Girl 1 'There's a little baby one.'
Girl 2 'No, it can't be.'
Girl 1 'Yes, it's longer than those two.'
Girl 1 'Oh yes, no, they're not, they are just the same.'

Two older boys made observations about the shape of the animals and their locomotion, with insightful interpretation linking their observations with previous knowledge in the following dialogue:

Boy 1 'They look strange, like a hammer head…'
Boy 2 'They swim like this on their back. They don't use their tails.'

Relating observations to knowledge about movement at this level was not heard from the younger observers, who only observed the means of movement. This older group had observed carefully and seen that these animals propel themselves by the legs and then realised that propulsion was not by moving the tail, as occurs in many fish. Such insight reveals progression in interpretation from that displayed by the six year-olds.

Some emergent scientists looked at the bottle ecosystems, and their contents, of their neighbours and made comparisons. Such observations could be developed systematically in the classroom, with measurements as further opportunity to develop problem solving, reasoning and numerical skills in the early years curriculum:

Girl 1 (one group) 'Our is much clearer water than yours.'
Boy 2 (next group) 'Oh! We've got more animals.'
Girl 1 'We can see ours better!'

The results from the emergent science-aged pupils would not be so meaningful without the knowledge of the more complex ones made by the post-emergent years children, who observed and commented more on behaviour, mating and identity of the animals.

Matching the science process skills required of children of different ages by the curriculum is often a requirement of the curriculum of the country of their residence. Using brine shrimp ecosystems offers the potential to develop various aspects of the curriculum. Through investigations, the specific observational and process skills can be practiced, whilst observations of the animals develop knowledge of biological science.

5.0 Conclusion and implications for teachers

Children readily identified the behaviours they saw and interpreted their observations by referring to their own lives. For children, watching brine shrimps at any age brings to the surface all sorts of feelings and encourages the children to observe and interpret and then raise hypotheses. Biological knowledge and understanding follows from a study of the animals, as children work out for themselves the concepts behind such things as ecosystems, adaptation to environment, abiotic factors in ecosystems, food chains, energy and biotic interactions. It is easy to observe reproduction, growth and the population dynamics of competition and predation. Brine shrimps are perfect classroom animals, as long as they have a light source. Children are fascinated by them and their study enhances not only the aspects of science investigation and process of life, but can also lead to numeracy and literacy work, as well as personal and social education. The behaviour of brine shrimps noticed by the children and interpreted by them revealed their understanding of mating and reproduction and can provide a basis for birth education (Tunnicliffe, 2010), when elements, for example, of sexual behaviour can be broached through referring to brine shrimp behaviour. Apart from the formal curriculum, the keeping of these delightful animals is a soothing and aesthetic influence in the classroom.

The questions raised by the children themselves are part of the developing ability to undertake inquiry through dialogic talk (Alexander, 2008), thus changing observations into inquiry. Once the pupils have become familiar with the animals, a teacher can discuss investigations using all the relevant skills of the science process, such as *'What do the shrimps live on?'. 'Where do the animals prefer to be in their environment in the bottle ecosystem?¸' 'Why do the animals swim in pairs?'.*

Observing the brine shrimps provides starting points for aspects of the early years curriculum and for further activities and discussions. Many young children interpret the typical behaviour of brine shrimps as mating. Some of the early years children went on to make written observations about romance and *Blind Date* (a topical television programme being aired at the time) in the brine shrimp world. Pupils can find out more about mate preference by giving either single males or females a mate choice of two different individuals, whether they like large or small or dull or brightly coloured partners. Children will identify with individual animals imaginatively and certainly develop their powers of observation, learning much without instruction and indeed improving on their hypothesis making.

Animals in the classroom are essential for meaningful biology. Brine shrimps cause no disease; they are living in their natural (artificially created environment), cause no welfare issues and are cheap. Furthermore, they require next to no attention other than a light source, so school holidays are not a problem. Undirected observation of living things is an essential part of the experience of emergent scientists and future informed citizens.

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Further information about brine shrimps can be found in the Brine Shrimp Book, which can be obtained from Homerton Brine Shrimp Project, Faculty of Education, Department of Biological Sciences, Hills Road, Cambridge, CB2 2PH

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Extended Abstracts

In this edition of ***JES*** we have included extended abstracts from two of the presentations delivered at the 2011 European Science Education Research Association (ESERA) Conference in Lyon, France. We hope to provide further examples in the next issue, so that you become familiar with the international researchers who are attempting to raise early childhood science education to the foreground through their research

Designing a learning progression for teaching and learning about matter in early school years

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Introduction

The atomic-molecular model of matter is one of the most important scientific models that permeate the science curriculum from early school years. Anchoring in this expert model, we want to support young students, aged from three years to nine years, to gradually develop more sophisticated understandings of materials while they engage in modelling the properties of, and changes in, these materials. Learning Progressions (LP), intended as *'descriptions of the successively more sophisticated ways of thinking about a topic that can follow one another as children learn about and investigate a topic over a broad span of time'* (NRC-USA, 2007), offer a working framework within which to think about how to accomplish this instructional goal.

By taking this LP framework, we work on designing a learning progression for matter with young students by examining two interwoven aspects: children's intuitive *ideas* and the *models* they produce. We focus on two complementary children's *ideas:* a) the understanding of macroscopic behaviour of materials (an observable visible continuum like water) through invented microscopic elements that are parts of these materials (discrete parts like 'tiny invisible drops of water'); and b) the understanding of these 'invented parts' as elements of structures, in which not just the characteristics of the parts, but the way they are connected and organised, play a role in understanding properties and changes of materials. Children's models are sustained by these *ideas,* and our focus includes looking at ways in which these models are constructed, used and revised, as well as supported by teacher-learning contexts. We focus on these two *ideas* for two reasons. First, the relationship between macroscopic and microscopic understandings is demonstrated to be useful but problematic for young children (Wiser & Smith, 2008). Second, in modern scientific interpretations of the behaviour of materials, the idea of 'particles organised in a structure' is being constantly refined and used to generate new knowledge (Laughlin & Pines, 1999). The way to think about this organisation of 'parts' matches the way to articulate a set of students' ideas around a 'parts model', which makes sense for young students in school contexts, allowing them to explain the behaviour of materials they are manipulating, and enables the model itself to develop.

Because we also want to provide teachers with concrete tools with which to support their students in understanding a sophistication of these *ideas* and *models* in a progressive fashion when they navigate the interpretation of the behaviour of different materials, we examine how these *ideas* are elicited and articulated in real classroom situations. Then, we include in the design of our learning progression instructional aspects that emerge supporting these sophistications. In particular, we focus on teachers' interventions and class-groups interactions; students' interactions with different materials; and the ways children represent and communicate the articulation of these ideas during these interactions.

The goal of this paper is to present a proposed learning progression developed with empirical support organised around two units of analysis: the articulation of two selected *ideas* as important dimensions through which to support students to construct and revise more sophisticated models of the properties of and changes in materials from pre-k to 4th grade elementary classrooms; and to report successes and challenges in designing the progression, including instructional aspects that emerge as supporting elements of the progression in real classroom situations.

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Context for the learning progression work
Data came from our own school-based research (Acher, Arcà & Sanmartí, 2007; Acher & Arcà, 2009). Participants were children (n = 20-24, ages from 3 to 9 years old), teachers, and the occasional participation of researchers immersed into classroom routines. Classroom lessons vary in length, from about 35 to 90 minutes, and number, from 8 to 14, reflecting differences in the age of children and types of activities in which they were engaged. Central to this research are designed classroom activities based on making children interact with materials and communicate their ideas about how materials behave under different conditions (e.g. treating them with fire, water or physical forces), using different ways of representing these ideas. These students-materials interactions are guided by teachers who support the articulation of students' ideas by following a relational outline based on a systemic view (i.e. the identification of parts, the relationships between parts, and the structure of relationships between parts); meanwhile, they also encourage children *'to imagine and to represent what may happen at an invisible level'*. Teachers also have the responsibility to assess with students the organisation of their ideas in students' scientific models, and get them involved in explanations and reconstruction of new aspects of the phenomena they are investigating. With these premises, teachers promote flexible modes of participation, involving children in whole group and small group discussions, and considered collaborative aspects of knowledge construction, viewing their own participation as a challenge for understanding how models could be constructed and revised. We collected different data: transcripts of small group and whole group discussions, and students' pictures and artefacts. Excerpts reported on in this article illustrate the levels of the progression derived from these sources.

The proposed learning progression
Our proposed learning progression starts by identifying a possible trajectory or articulation of ideas and models – not a unique one and not a 'developmentally inevitable' one. Due to space limitations, we report this trajectory as a list of ideas below, leaving, for another published paper, a deeper illustration of our progression with evidence from different school years:

- Distinction between proprieties of objects and properties of shapes;
- Ideas of parts and large quantities of parts;
- Idea of the quantities of the parts;
- Idea of bonds between parts; and
- Ideas of relating changes in materials with changes in the way these parts are bonded, and change in the ideas of the parts themselves.

We decided to provide a piece of evidence that illustrates the potential of this progression for supporting students' sophisticated understanding of material behaviour. Below in Figure 1 we show one of our findings in which 3rd grade students (8 years old) modelled the transformation of water based on the ideas of parts/structures.

Balloon filled with water   Breaking water with afoot   Breaking water with fire

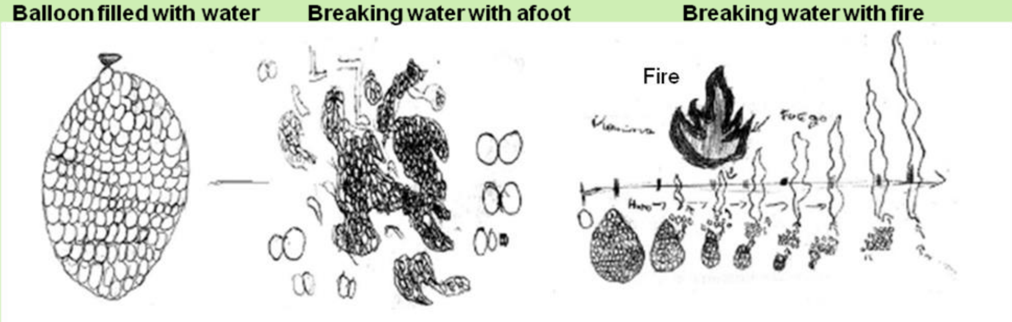

Figure 1: Transformation of water
Teacher: 'This time we're going to break our shapes by putting them in the flames of the fire. Then we're going to discuss what you think happened to each one of the parts you used to describe your shapes in drawing number 1. Also, when you are doing it, say what's happening as time goes by with your material in the fire. Use as much detail you want in your explanation'
Child 1: 'I can see in all our drawings the same parts of water going away, little by little'
Teacher: 'What is this 'steam'?'
Child 2: 'It's the parts that are separating, there are fewer and fewer in the water and there's more steam'.

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Figure 1 shows a sequence of drawings and an excerpt illustrating a sophistication of 3rd grade students' models of water. From left to right, the first drawing shows water represented as a 'large quantity of parts'; the second represents water broken down with a foot, and a detail of how two single parts are bonded together; and the third shows how the previous two drawings/ideas are used to explain what happened to water when is heated or 'broken by fire'. The excerpt shows how students use their previous models with ideas of parts to build explanations that account with transformation and conservation of these parts. (Note that parts do not disappear and do not change their shape either. There is also an apparent proportional relation between the disappearance of parts and the appearance of 'steam').

Successes and challenges in designing the progression

We found that, through the kind of sophistication illustrated above, students practised the explanatory power of a model of 'parts/structures.' They were also confident in explaining some changes in materials by figuring out modifications of the imagined parts; other changes were explained by identifying alterations in the bonds between parts and variations in the spatial distribution of the parts. This put them in good stead for increasing the sophistication of their understandings of transformation of materials. When we examined instructional aspects that emerge as supporting elements of the progression, we found some ways students interact with materials (manipulations) critical. As an example of successful productive manipulation, we found that through grinding, crashing, crumbling, stepping on, and beating 'whole materials', children moved on to imagining, first, 'parts,' and then a 'large quantity of parts'. Another instructional aspect that emerged as successful in supporting the progression was when teachers engaged children in multi-representation tasks, creating a classroom dynamic by which drawings, gestures or physical constructions were taken as concrete tools (resources) to compare perspectives and meanings that might have been beyond children's intentions. These moments showed teachers persuading children to reason on the grounds of comparing these representations, using them to support model revisions.

Finally, as researchers, we accept the challenge of integrating aspects of content-related ideas, scientific practices such as modelling, and instructional aspects in the design of our learning progression. By studying the future and limitation of the learning progression, we start to design for teaching and learning about matter in early school years.

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Semiotic mediation and the didactical cycle as a methodological reference for primary school teachers

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Definition of the problem

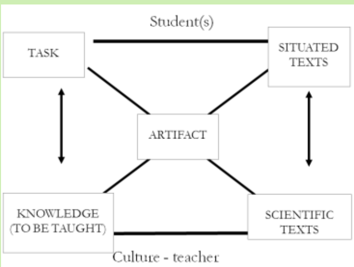
Some primary school teachers have difficulties in teaching science and, in particular, in driving laboratory activities, addressed to encourage early science thinking, to achieve a lasting effect of science education. Science laboratory activities risk being reduced to a set of trivial practices, or mere manipulation, or twiddling, to be executed by children, without suitable and precise teacher's guidance, while, according to the Vygotskian perspective of *obucenie* (Mecacci, 1990), the teacher's active role is fundamental. In literature or in textbooks, a wide variety of educational school courses is documented, while effective methods on teaching /learning processes are not so widely available. In this contribution, after a synthetic presentation of a proposal of a methodological framework, an example of a semiotic approach to introduce children to energy meaning construction will be presented and discussed.

Its place in the literature

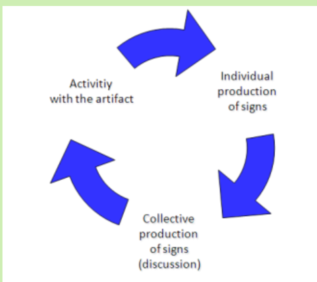
In mathematics laboratory education, there exists a well-defined and consolidated framework of semiotic mediation (Bartolini & Mariotti, 2008) to guide and foster methodological and educational competencies in teachers. This fits a Vygotskian tradition that considers learning a mediated relation between individuals and knowledge. Artefacts and instruments are key terms of Rabardel's theoretical construct, which defines an instrument as *'a mixed entity made up of both artefact-type components and schematic components that we call utilization schemes. This mixed entity is born of both the subject and the object. It is this entity which constitutes the instrument which has a functional value for the subject'* (Rabardel & Samurçay, 2001). However, Rabardel's approach is not enough to be used in teaching/learning processes in which Vygotsky's analysis of technical (artefacts) and psychological (sign)[1] tools, and Hasan's (2002) investigation of complex semantic relations of mediation processes are necessary. In the learning process, a child needs the help of the teacher to cross the Vygotskian zone of proximal development and to internalise new knowledge.

Outline of the argument put forth

The key terms of Bartolini and Mariotti's (2008) framework can be reinterpreted to suit the specific case of science. Figure 1 reports the sketch of the elements and the links of the theoretical framework of semiotic mediation adapted for science.



a



b

Figure 1: Elements and links of the theoretical framework of semiotic mediation (a) and the didactical cycle (b).

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At the centre of the laboratory work there is an *artefact*. The artefact may be any scientific 'instrument' available in scientific laboratories (easily assimilated to mathematics artefacts and to Rabardel's *genèse instrumentale*), or the reproduction in the laboratory of a piece of reality, according to the analysis of Knorr-Cetina (1999), with the aim of simplifying and focusing particular aspects. The artefact embodies meanings that pupils have to discover and internalise, and this is stimulated by the *task*. The task, a question or a problem posed by the teacher, reflects the fundamental steps of scientific research. The task may refer, for example, to the description of the artefact itself and of the function of its parts, or to the prediction of its behaviour under certain conditions, the solution of a problematic situation, the way to achieve a certain result, the description of a process or of a phenomenon involving the artefact, its interpretation and the identification of relevant invariables, as well as their relations. A child's individual answers and hypotheses can be improved if s/he is requested to imagine and to embody the different physical object or the different quantities involved in the processes (Mariani *et al,* in press).

The children, stimulated by the task, construct personal meanings through *utilisation schemes* of the artefact, i.e. from simple manipulation and exploration of the artefact, to well-designed experiments with choice of the parameters and the quantities to be varied and measured. The teacher's role here is again fundamental and well defined. By all these activities, children produce some *signs* that the teacher may recognise and interpret as 'pivot' signs. Pivot signs may be used by the teacher to create a link between the plane of concrete experience and the plane of meanings. This is done through an iterate cycle that includes the activity with the artefact, the individual production of the sign, and the collective discussion pointing at the shift between the *situated texts* produced by the children to forms of *scientific texts* (suitable to pupils' age) that are decontextualised from the specific situation and, at the same time, able to evoke the concrete experience.

Contents of a possible teacher training path for energy meaning construction

In order to apply this methodology, teachers need first to be trained, putting themselves in the same situations (i.e. using the same artefact, answering to similar tasks, producing and discussing the pivot signs that they expect from children) that they could offer to their pupils, thus to experience the possible difficulties and needs of children, and to focus science knowledge in relation to children's experiences urged by the artefact use as an *instrument.* In the following, we outline an example of the contents of an application of the semiotic mediation framework addressed to teachers with children aged 8 to 10 years. We will refer to the elements shown in Figure 1.

The piece of knowledge to be taught: The concept of energy is very hard for young children to understand. However, some basic concepts can be introduced very early to prepare the scientific meaning construction in a vertical curriculum perspective, i.e. teacher-guided identification and differentiation of the *Force-Dynamic Gestalts* (Fuchs, 2007; Corni 2011).

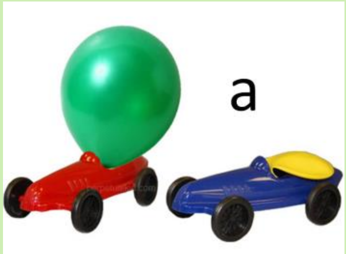

Figure 2: The jet-car artefact.

1: The sign acts as an instrument of psychological activity in a manner analogous to the role of a tool in practical activity.

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The artefact: Consider a jet-car toy (Figure 2). Other artefacts can be, for example, a put-put boat, a windmill, a dynamo torch or, with reference to natural sciences, a tree, an ecosystem, the blood circulation, the water cycle, or chemical reactions.

The task: The tasks, with reference to the jet-car, can be classified as: (A) the exploration of the toy (describe the jet-car and its component parts); (B) the utilisation schemes of the toy (how could you use it? How could you make the car go faster? Or go further?); (C) the use of the toy with utilisation schemes (after the experiments: What did you do with the jet-car? What did the car do? How do you explain your observation?); (D) the detailed analysis of the toy (balloon inflated and exhaust hole kept closed): What quality does the air in the balloon have? How does the air 'feel'? What qualities does the jet-car have?; (exhaust hole open): What quality has the air while it is coming out of the hole? How does it "feel"? What qualities does the air have after it has come out of the hole? How does it 'feel'? What qualities does the jet-car have while the air is coming out from the hole? How does it 'feel'? What qualities does the jet-car have after all the air has come out of the hole? How does it 'feel'? Each task generates a didactical cycle.

The evolution of situated texts towards scientific texts: In a real case, for every task children produce sentences, words, expressions, drawings, sounds, and gestures that the teacher may recognise as pivot signs. For example, during a collective discussion, pivot signs could be: 'air is trapped', 'a wind exits the hole', 'air mixes with outer air', 'the car moves forwards while the air is blown out', 'the car gradually stops', 'more air–more speed', 'all are resting'… Teachers have to be trained to conduct collective discussions for gradual construction of scientific meanings, starting from the pivot signs. The steps in the case of energy could be:

i. description of the process as a whole using common language;
ii. refinement of the language used, stressing quanlities that play a role;
iii. description of the process in terms of fluid-like quantities, associated differences of potential and elementary concepts (current, resistance, capacitance, etc.);
iv. interpretation in terms of cause-effect (so far, the word 'energy' is still not used); and
v. introduction of energy as proportion between causes and effects.

A possible scientific text that teachers should make is the following:

When the balloon deflates, the car accelerates, reaches maximum speed and gradually goes to rest. The air expelled backward pushes the car forward. The car moves but, at the same time, loses motion. After the balloon is completely deflated, the car loses all its remaining motion and stops.

More formally: *The air expands due to the pressure difference and exits at high speed from the car nozzle. Thus momentum is transferred to the car proceeding in the opposite direction. The car accumulates momentum and, at the same time, transfers part of it to the earth as a consequence of the velocity difference. When all air has been expelled, the car momentum gradually flows to the earth until the velocity difference becomes zero. The air pressure causes the transfer of momentum from the air to the car, air interacts with the atmosphere and car interacts with earth causing production of heat. The energy contained in the compressed air is transferred to momentum (a greater fraction to the air than to the car) and from momentum to heat.*

Conclusions

We have proposed a methodological framework of semiotic mediation and the didactical cycle to introduce to teachers as a reference for scientific meaning constructions in laboratory activities. Its foundations are taken from a well-defined and experimental framework for the mathematics laboratory. The various elements and links have been discussed and exemplified for the case of energy meaning construction.

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ISSN 2046-4754

News & Notes

The Emergent Science Network

The Emergent Science Network was established in 2007 to:

- facilitate communication between people interested in emergent science;
- develop understanding of young children's scientific development;
- support professional working with young children; and
- evaluate the impact of emergent science research on early years pedagogical practice.

The network provides an important communication link between professionals, academics and others interested in early years science from across the world. Members receive three newsletters a year, collaborate on research, presentations and publications, and communicate ideas and support each other. The latest Emergent Science Newsletter can be found through the following link **http://www.bishopg.ac.uk/emsci**

If you wish to join the network (there is no cost involved), please contact Jane Johnston at **j.s.johnston@bishopg.ac.uk**

ASE Annual Conference 2012, University of Liverpool

Running from Wed 4th to Saturday 7th January 2012 at the University of Liverpool, this enormous educational event is open to all, members and non-members of ASE. Full details can be found at **www.ase.org.uk** and it is important to note that there is a full primary programme, including some early years sessions. A varied programme coupled with a huge exhibition of books, resources, software and equipment makes this the CPD event of the year for science education professionals. Some sessions to note are:

- Adam Hart-Davis giving the Margaret Collis ASE Primary Science Lecture, *Science Outside the Classroom*
- Science through play: developing scientific thinking in young children
- Talking science education
- Science and Innovations Observatory
- Practical activities for pupil-led family fun days
- Select any story, take any toy
- A range of TTS workshops

…and many more.

For more information, please visit the ASE website (**www.ase.org.uk**) and click on Conferences, or contact the ASE Conferences team on **conferences@ase.org.uk**

Cambridge Primary Review Network

You can contribute to the new Cambridge Primary Review Network, which:

- aims to build reflectively and critically on the ideas, principles and proposals in the final report of the Cambridge Primary Review (CPR);
- is securely grounded in sustainable evidence, whether from the CPR or other sources;
- enhances professional and institutional capacity in the interests of replacing prescription, compliance and dependence by knowledgeable and accountable professional autonomy; and
- improves the quality of primary education experienced by all the nation's children, but especially those who have given the CPR particular grounds for concern: the disadvantaged, the vulnerable, the marginalised, and those who for whatever reason are unable to benefit from the best that primary education can offer.

More information about the Network, the regional centres and how you can contribute can be found on the CPR website: **http://www.primaryreview.org.uk/**

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News & Notes

Implications for science education from the Tickell Report

The Tickell Report, *The Early Years: Foundations for life, health and learning: An Independent Report on the Early Years Foundation Stage to Her Majesty's Government* was published earlier this year. A response from ASE can be seen at: **www.ase.org.uk** Below are some comments and questions relating to science education in the early years.

Science as a core area of learning

The Report recommends that science, as part of '[Knowledge] and Understanding of the World', is one of four specific areas in which the prime skills of learning are applied. The other three are literacy, mathematics and expressive arts and design. This recognises the part played by science education, together with technology, ICT, geography, history and citizenship, in young children's holistic development. This is to be applauded, as the importance of science as a core aspect of the curriculum has been diminished at later stages of development.

The Tickell Report recommends 'Understanding of the World' as part of the core curriculum. Do you agree with this? How important do you feel science is as part of 'Knowledge and Understanding of the World'?

Personal, Social and Emotional Development (PSED)

An important aspect of the Report is the emphasis on PSED as *'essential foundations for children's life, learning and success'* (p. 6) and that the PSED skills (and attitudes?) are applied in the four specific areas of learning, including 'Understanding of the World'. This is recognition of the part played by PSED on children's cognitive development and is something that should be considered, not just in the EYFS, but in all phases, as this would ameliorate the negative attitudes some children have towards science at later stages. It is good to see that the Report draws upon the quality research in this area.

How important do you feel PSED is in supporting the scientific development in the early years? If so, why?

Pedagogy

Playing and exploring, active learning, and creating and thinking critically are highlighted in the EYFS as three characteristics of effective teaching and learning, and the recommendation is that play continues to be a key pedagogy, but there is no clarity about what this means at different stages of the EYFS, nor how it can incorporate direct teaching in a meaningful way. The Report discusses the importance of *playful adult-directed learning* (p.35) in science, but what this means is not really discussed. Research and experience indicate that playing and exploring are not well understood and in the context of early years science this is more so, maybe because early years professionals lack confidence and expertise (subject knowledge and subject pedagogical knowledge) in science.

How might play, exploration, critical thinking and creativity be effectively used to support early years scientific development?

The role of home and parents

The role of parents in early years development is a major aspect of the Report and an aspect that ASE (in the more distant past) supported through some publications.

How can professionals and parents work together more effectively to support scientific development?

Support for professionals in understanding the curriculum

The Report recognises that there will be less support in the future to help early years professionals and that the new framework should be *'redrafted in such a way that the framework is easy to access, understand and navigate, incorporating what is known about how young children learn'* (p.17), and that support should be provided in an accessible way. It is difficult to slim down the curriculum (from 69 to 17 early learning goals), without actually reducing the curriculum, and so it is difficult to see how meaningful support can be provided. The Report indicates the need for a *'strong, well-qualified early years workforce'* (p. 7) and, whilst higher level qualifications for early years is to be applauded (together with the monetary reward for such higher qualifications), this should include support for specific aspects of the curriculum (both subject and subject pedagogical knowledge).

What support do you need to support scientific play and exploration?
Is this support currently provided in the EYFS?
Will slimming down the EYFS provide the support you need?

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News & Notes

Creative Little Scientists

Creative Little Scientists: Enabling Creativity through Science and Mathematics in Preschool and First Years of Primary Education is a collaborative research project funded by the European Commission's 7th Framework Programme. The project involves creativity experts and early years science and maths experts from across European universities:

- the Institute of Education in London
- the Open University
- Bishop Grosseteste University College Lincoln
- the University of Eastern Finland
- Artevelde University College in Belgium
- Goethe University Frankfurt
- the University of Minho in Portugal
- the National Institute for Laser, Plasma and Radiation Physics in Romania
- the Université de Picardie Jules Verne, France
- the University of Malta
- and led by academics from Ellinogermaniki Agogi in Greece.

Over the next two years, the research will be carried out in nine European countries, chosen because they represent a wide spectrum of educational, economic, social and cultural contexts, as well as a wide spectrum of practices regarding science and mathematics education in general, science and mathematics education in early years, and creativity in education. The project has a number of work packages that will develop a conceptual framework, collect data that maps, compares and analyses existing practices in creative early years science and mathematics, provides directions for teacher training, and disseminates the research findings. The project began with a launch in Greece at the beginning of October and the first work package is already under way. We expect to be able to give you updates on progress in future editions of ***JES***.

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Resource Reviews

Planting the Seeds of Science. A flexible, integrated and engaging resource for teachers of 3 to 8 year olds, 2nd Edition

This book, which is accompanied by an interactive CD, is designed to provide flexible support for early years professionals working with children aged from 3 to 8 years of age. It contains five modules, with themes of the environment, astronomy, forensic science, cleanliness and solar energy, which are designed to build on the professionals' expertise in early childhood learning and development and support and develop scientific subject knowledge. Each module has between six and nine sub-themes, with a starting point that relates to the children's everyday experiences; Module 1 uses a starting point of *Our Trip to the Park*, whilst *The Sun Changes Everything* uses the Australian experience of a frilled lizard warming itself in the sun as a starting point. This weakens the relevance of the book to UK professionals, but a suitable alternative could be found, using British native animals, such as a hedgehog or frog.

As well as the sub-themes, each module contains an overview, an introduction and focus questions, and finishes with questions and answers, resources to support the module, curriculum integration, links to the Australian early years framework and science curriculum and finally a case study. The case studies illustrate how a range of professionals has used the module with early years children.

Although the book was written with an Australian audience in mind, it is a good resource for UK professionals. The curriculum integration section makes good links between science and other areas of learning/development and, whilst this is also evident in the activities in each sub-theme, the science could be overlooked; it is so well embedded as to not be a threat to the less confident professional, but may as a result be missed and de-emphasised. However, the Question and Answer sections contain the science subject knowledge underpinning the module and this is supportive of professionals who want to develop their understanding of the science behind the activities in which they engage with children. For example, the module *Muds and Suds: The Science of Cleanliness* looks at the chemistry of soap and *Is the Grass still Green at Night? Astrophysics of the dark*, answers questions such as 'What is the Sun?', 'Why does a shadow change shape?' and 'Why can't I see the Sun at night?'

The book is limited in two respects; firstly in its reference to the Australian curriculum and experiences and, secondly, in that it does not look at how the experiences in the modules could be used with children under 3 years of age. Regardless of this, the book would be a good resource in the early years setting, complementing the ASE/ GA publication *The Curriculum Partnership: Early Years Handbook*, which could be similarly updated.

Jane Johnston

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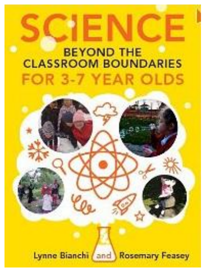
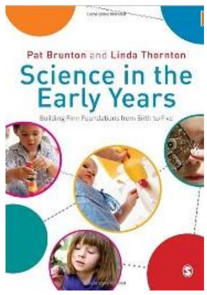
Authors: Christine Howitt and Elaine Blake (Eds.)
Published 2010 by Australian Learning and Teaching Council
Paperback, 128 pages
RRP: Free under Creative Commons Licence available
http://www.altc.edu.au/resource-planting-seeds-science-second-edition-2010
ISBN: 978-0-646-54920-0



Science Beyond the Classroom Boundaries for 3-7 year olds
Authors: Lynne Bianchi and Rosemary Feasey
Published 2011 by McGraw Hill
Paperback, 136 pages
RRP: £19.99
ISBN: 9780335241293



Science in the Early Years: Building Firm Foundations from Birth to Five
Authors: Pat Brunton and Linda Thornton
Published 2009 by Sage Publications
Paperback, 200 pages
RRP: £20.9
ISBN: 978-1-84860-143-7

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Resource Reviews

Science Beyond the Classroom Boundaries for 3-7 year olds

At last, a book urging us to leave the classroom and learn outside it, not on field trips to zoos and museums and so forth, but in the immediate school area, hard-surfaced playground, or fields with nature areas. The authors' aim is to change teachers' perceptions of where science can be taught from the idea that it is purely a classroom-based activity. This is an innovative whole school approach to teaching the science curriculum, and the whole curriculum, outside. This book contains practical examples for teachers in schools from around England, where the activities in this approach have been tried, and the philosophy is based on one version of the GROW model (Goal-Reality-Options-Will or Way Forward), which are subheadings used in the eleven ensuing chapters.

These are, beginning with Chapter 1: *Transforming Science* beyond classroom boundaries, with a rationale and discussion of the reasons why many teachers stop using the outside areas as children progress through primary school. Chapter 2 identifies the potential for science 'beyond the classroom', whilst Chapter 3 considers the development of the personal capabilities of children through these out-of-classroom opportunities. Chapter 4 shows how teachers can manage the children working at science in the alternatives to the classroom environment. Health, safety and risk are considered in the next chapter, with ideas for encouraging the children themselves to assess risks too. Progression and assessment is key to our teaching to help children learn. This, and how teachers can check their own progression, is dealt with in Chapter 6. The important issue of resources is discussed in Chapter 7, with useful suggestions for outside classrooms, such as science bags and haversacks (in common with many zoos), with an extremely comprehensive table of activities, each with the resources needed, activity suggestions and the personal capabilities that could be developed through such activities. Charles Darwin walked, observed and thought; Chapter 8 suggests how to set up 'thinking paths' in the school for children to use when working in science, and then provides some practical ideas for use. Science plant sheds are introduced in Chapter 9, with rationale, options and then suggestions for themes with science links, essential personal capabilities. Finally, 'Story Sacks' for science are suggested, with suggestions for books related to science.

A final chapter sets out visions for the future, challenging the reader to progress the ideas put forward in the book. Each chapter contains examples from case studies from those schools that participated in the project, as well as many practical suggestions. These provide extremely useful guidance and ideas for schools extending their provision for children's learning experiences to beyond the classroom walls.

Sue Dale Tunnicliffe

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Published 2010 by Australian Learning and Teaching Council
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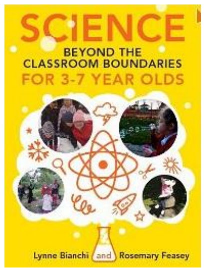

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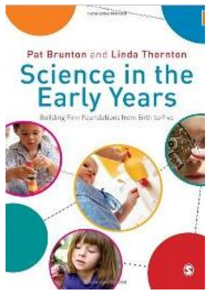

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Resource Reviews

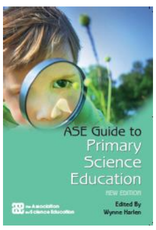
Science in the Early Years: Building Firm Foundations from Birth to Five

This book is just what it says it is and is an essential handbook for educators planning programmes for children from 0 to 5 years. The introduction provides an overview of the role of science in the lives of these young children, emphasising that such crucial experiences must start with the child. It discusses briefly the needs of boys and how to involve parents in their children's learning, before summarising the place of science in the curriculum frameworks of the UK. The authors stress that we need to acknowledge these early learners as both competent and creative thinkers with ideas of their own. Thus, the role of the adults alongside them is to support these child-generated initiatives in learning, through providing relevant resources and talking with the learners.

Part 1 discusses how young children's scientific learning develops, summarising what it is that makes science-conceptual, attitudinal and procedural knowledge and how these can be developed, emphasising the role of the adult as the partner in constructing this knowledge, through asking productive questions, observing the children and being aware of the spiral of discovery in babies, toddlers and then schoolchildren. Chapter 2 outlines how to create a science-rich environment through, for example, organising both indoor and outdoor environments, as well as pointing out the vital role of assessing risk and meeting challenges that arise in play, and nurturing development of science understanding, suggesting useful tools and equipment.

Part 2 consist of ten chapters, each dealing with an area of science: living things; habitats and sustainability; the structure of the human body and healthy living; materials; forces; air and water; magnets and magnetism; electricity; sound; light, colour and shadow, and the Earth. Each of these chapters begins with a summary of the science content for the adult to refresh his/her memory of secondary school science, and goes on to illustrate contexts of learning for that topic, with a section for the three early years stages illustrated with snapshots of a child enjoying a learning experience. Each section suggests activities, together with observations the adult may make in order to assess the child. Each chapter ends with a vocabulary to use and a list of equipment and resources, as well as a few suggestions for further reading. There is an index and a list of references cited in the text.

Sue Dale Tunnicliffe



Erratum

In the review of the new *ASE Guide to Primary Science Education* featured in *JES* issue 1, the wrong cover was inadvertently used. We apologise for this and show here the correct cover. The *Guide* is available through ASE Booksales (**www.ase.org.uk**) priced £19.00 to ASE members and £25.00 to non-members.

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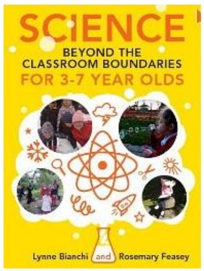

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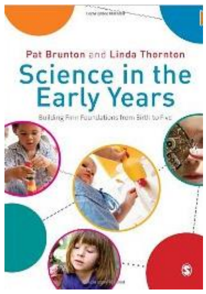

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