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Editorial

■ Jane Johnston

You can be forgiven if you are confused by the mixed messages about effective early years and science education and the part played by research in policy decisions. We are told that teaching should be a research-informed profession (DfCSF, 2007), that it is important to have professionals who are knowledgeable about the subject (NSLC, 2013), as well as how to teach the subject (e.g. Oversby, 2012). Extensive research and practice has told us that children learn best through experience and play (e.g. Johnston, 2013), that formal education should start at age 7 (*The Telegraph*, 2014). However, within the UK, we have been told that mathematics and physics PhD graduates do not need pedagogical knowledge or skills and will get cash incentives to teach (BBC News, 2014b) and that children should start formal education as young as 2 years of age (BBC News, 2014a).

The really worrying aspect of the mixed messages is that pronouncements about what is good education, and even important policy decisions, are made by those who have little or no expertise in science or early years education. So, politicians decide what, how and when children should learn about the world around them, as though children are not learning through exploration, experiences and interactions in their everyday, playful lives. Experts in one aspect or phase of learning feel able to extrapolate from this to another aspect or phase of learning. Most commonly, it is those with secondary science expertise who extrapolate from their secondary research or practice about what early years or primary science education should be. However, those who are scientists first and educationalists second may also have a very different stance on science educational research from those who are educationalists first and scientists second. All early years science professionals are skilled educationalists who also have a science expertise, and so they are best placed to know how young children can develop scientific understandings, skills and attitudes through engagement with the world and scientific phenomena around them.

The mixed messages we receive confuse parents and the general public who are often too trusting of the misplaced expertise as, surely, the Secretary of State for Education 'knows best' and so the early years science professional's expertise is devalued. However, to use a health analogy, we would wisely be concerned if a politician or a general practitioner told a neurosurgeon how s/he should operate on a patient and yet we are more accepting of similar poor practice in education.

The research published in *JES*, which represents best practice in early years science education, is unequivocal about the nature of early years science education. In this edition of *JES* there are some key messages from research; the importance of creative, informed interaction between children and adults; and how very different approaches can support children's scientific understandings. There is evidence that creative drama techniques (Kambouri and Michaelides) and dynamic interventions (Pedregosa *et al*) can facilitate learning in young children. In addition, the research indicates that an interdisciplinary approach (Blasbalg and Arroio), interest and pupil autonomy (Windt *et al*) and teacher interaction (Emeji), as well as encouraging children to read about science (Yamahashi *et al*) support scientific understanding.

We have come a long way in early years science education and our voices are being increasingly heard. Findings from our research and scholarship are impacting on practice and provision. What we should be saying loudly and clearly is that effective teaching and learning in early years science is a complex process, that there are many factors affecting it and that we should listen to the professional research rather than the rhetoric of governments.

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Jane Johnston

Co-Editor of the *Journal of Emergent Science.*

Contributing to the Journal of Emergent Science

Instructions for authors

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 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

Please send all submissions to:
janehanrott@ase.org.uk in 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 and shorter reports of work in progress or completed research of up to 2,500 words. In addition, the journal will review book and resources on early years 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 Times New Roman point 12 with double spacing and with 2cm margins.

- 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

Guidance on referencing:

Book

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

Vygotsky, L. 1962 *Thought and Language.* Cambridge. MA: MIT Press

Chapter in book

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

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

These should be addressed and sent to Jane Hanrott (JES), ASE, College Lane, Hatfield, Herts., AL10 9AA.

Using drama techniques when teaching science in the early years: A case study

■ Maria Kambouri ■ Anthia Michaelides

Abstract

This paper investigates the effect of drama techniques when employed to facilitate teaching and learning early years science. The focus is a lesson intervention designed for a group of children aged between four and five years old. A number of different drama techniques, such as teacher in role, hot seating and miming, were employed for the teaching of the water cycle. The techniques were implemented based on their nature and on what they can offer to young children considering their previous experiences. Before the beginning of the intervention, six children were randomly selected from the whole class, who were interviewed, aiming to identify their initial ideas in regards to the water cycle. The same children were interviewed after the end of the intervention in an attempt to identify the ways in which their initial ideas were changed. The results appear to be promising in terms of facilitating children's scientific understanding and show an improvement in the children's use of vocabulary in relation to the specific topic.

Keywords:
Early years education; drama; science

Introduction

In an early years classroom, we can observe a variety of children who have different learning needs and knowledge. By taking this diversity into consideration, teachers should offer students a range of different and equally important learning prospects (Rubin & Merrion, 1996). There is good evidence that the arts are a way of reaching and engaging children, with diverse learning styles, fostering and supporting social growth, unifying content and of powerfully communicating meaning (Rubin & Merrion, 1996). Through the arts, children can better understand themselves and others (Rubin & Merrion, 1996). Thus, via the arts in education, children can improve and consolidate their learning.

It has been generally acknowledged that by using arts-based teaching and learning, in general, learners are able to express themselves as well as their knowledge through different, creative and novel approaches (Goldberg, 1997). Goldberg (1997) stresses that the arts play a fundamental role in teaching and learning, since they provide challenges and opportunities to children in exploring their own questions and queries. Such approaches also serve as a mode of expression when working with ideas and feelings. Research also supports the notion of arts providing and amplifying pupils with opportunities to take on more risks in their learning (Burton, Horowitz & Abeles, 1999). Hence, the positive and constructive role the arts play in engaging children's learning can be acknowledged. One of those art forms considered to be of great use in this context is drama.

However, there are very few studies on the use of drama for science education (Yoon, 2006). This paper attempts to examine the potential of employing drama techniques to aid the children's understanding of specific scientific ideas. The intention was to develop and employ an intervention lesson, based on the children's age and previous experiences, which utilises a number of different drama techniques. The paper describes a science lesson that was designed specifically for the topic of the water cycle by two teachers/researchers; the first one has experience in using drama techniques with early years children; the second has a special research interest in teaching science in the early years. This enabled the development of a lesson intervention that blended the expertise coming from the two complementary fields.

The learning of science

When investigating ways that can help children's learning of science, it is important to refer to the way in which children learn science and construct their knowledge. Children's concepts are thought be formed as a result of previous experiences. Much of young children's scientific learning comes from the varied environment in and around their homes, the information that is shared around them and the demonstration of skills by close adults, such as their parents (Bradley, 1996; Hollins, Whitby, Lander, Parson & Williams, 2001). Children's scientific views are a result of personal experiences, which can include watching television, reading books and oral language interactions in addition to the interaction with family members and other adults (de Kock, 2005; Guest, 2003). As a result, children develop their ability to think and construct concepts based on their experiences and interactions.

As Guest (2003) contends, concept development is not just a case of becoming faster or fuller of knowledge; there are also qualitative changes in the way that children process new information as they develop cognitively. Science education needs to consider these qualitative changes and needs to engage participants in active participation (Yoon, 2006). However, science educators usually prefer to demonstrate experiments and organise investigations to collect evidence, plan observations and develop logical thinking (Yoon, 2006). Teachers might fear that actively engaging children might lead to 'losing classroom control', since control is usually perceived as the structure that a teacher applies to classroom management (McSharry & Jones, 2000). Consequently, the way that science is typically taught in schools with older children tends to be very information-driven (Lobman & Lundquist, 2007). The children who benefit more from this type of teaching are the ones who are already familiar with the concepts through previous out-of-school experiences. In the last few years, researchers have confirmed that middle class children come to school with life experiences that provide a foundation on which school learning can occur. These children can access the science curricula because they have prior knowledge and/or experience (Lobman & Lundquist, 2007).

Drama and science education

Combining the literature and research about drama on one hand and science on the other reveals that some similarities exist. The fact that both offer children the engagement in active participation of meanings and understanding was the core of this study. Grainger (2003) portrays drama as the art that involves social encounters and which offers particularly rich and affective experience for both teachers and children. Drama enables both children and teachers to enter a world of experiences and knowledge. Through drama, children are given opportunities to construct and analyse new ideas and additionally reconstruct and produce new understandings and meanings (Grainger, 2003). Neelands (2002) points out that children have the tendency to learn by experiencing and acting out, all of which can be illustrated through drama (or can be thought of as dramatic ways of demonstrating learning). Through drama, children are given the opportunity to construct their own knowledge by allowing them to have control over this knowledge (Avdi & Hatzigeorgiou, 2007). In addition, the notion of drama contributing to children's learning of science can also be considered as a creative and innovate aid and a means for teaching knowledge that is otherwise difficult to achieve through conventional educational approaches (Metcalfe *et al*, 1984; Sergi, 1991).

Drama has frequently been acknowledged as a means by which to teach different curriculum subjects, as well as a curriculum subject on its own that facilitates and enhances children's learning (Winston & Tandy, 2001; McGregor, 2014). The benefits of applying drama in teaching vary from externalising emotions and feelings (Sergi, 1991) and reflecting upon their experiences and relationships regarding the world and people around them (Smith, 1983), to enriching children's vocabulary and comprehension of language (Rubin & Merrion, 1996). Drama techniques are also seen to have a positive effect in developing children's vocabulary and language comprehension, usually due to the use of dialogue (Rubin & Merrion, 1996).

There have been several examples of drama's usage in curriculum subjects (including science) as a means to construct knowledge (Scher & Verrall, 1975; Sergi, 1991; Winston & Tandy, 2001; McGregor, 2014). Research regarding the use of drama activities in science has indicated the positive role that drama has on children's learning as an aid to expressing meanings and understanding (Metcalfe *et al*, 1984; Varelas *et al*, 2010). Metcalfe *et al* (1984) report that, although no statistically significant differences were found in the effectiveness of using drama in science in primary ages, drama gave children an insight into science meanings. Moreover, Varelas *et al* (2010) suggest that primary children enact science meanings through drama improvisations; hence, drama can offer children a different perspective of science and can enrich science learning through offering experiences as well as knowledge. Drama activities can offer opportunities to children to express and construct scientific ideas in conversation with their teacher and their peers about the phenomena and topics they study, while they can also enable children to reconstruct scientific meanings (Varelas *et al,* 2010).

In addition, Dorion (2009) noted that positive outcomes were found when drama was used in teaching chemistry, biology and physics in secondary school. The same author (2009) reports that employing drama techniques for the teaching of secondary science can assist students' understanding of more abstract scientific topics. Braund *et al* (2013) also report that using drama in science lessons enables students to experience a phenomenon. McGregor (2012) similarly reports that, when teachers employ drama for the teaching of science to children from five to seven years old, both children and teachers benefit. This is because drama enables teachers to get an insightful view of children's perceptions, thoughts and understandings and stresses the view of implementing innovative approaches to teaching science (McGregor, 2012). A more recent study by McGregor (2014) indicates that the use of drama techniques for the teaching of primary science engages and motivates children and also aids them in grasping more challenging conceptual and procedural ideas.

According to Precious and McGregor (2014), children agree that the use of drama techniques can support them in many areas of scientific enquiry and help them understand scientific ideas that are traditionally thought to be difficult. The majority of the children report that these activities are both fun and help them learn science, through acting out and talking about their ideas (Precious & McGregor, 2014). The beauty of using drama for the teaching of science is that it allows children to develop their understanding of emotional and behavioural real-life events in a safe way (McSharry & Jones, 2000). The use of appropriate drama techniques can offer children the opportunity to learn without worrying about what they do or do not know (Lobman & Lundquist, 2007).

There are a number of different drama techniques that can be applied in a science classroom: techniques such as hot seating, teacher in role, still image, mantle of the expert, action narration, mime, thought tracking and many others (Neelands & Goode, 2000; Avdi & Hatzigeorgiou, 2007). The structure of these techniques allows children to say or act out things that are beyond what they would in other circumstances say or do under more traditional school conditions (McSharry & Jones, 2000). Drama techniques can introduce children to the terminology of the science topic in a supportive environment. For example, in creating an improvised scene that takes place on the moon, one child might begin walking in a funny way and the group could then use this to discover how they might move in a gravity-free environment. Each child does not need to worry if he or she knows anything about gravity; they just need to follow the game (McSharry & Jones, 2000). However, several factors need to be taken into consideration when it comes to applying drama in science education, such as the age of the participants as well as their experiences in relation to drama and the topic under investigation (Avdi & Hatzigeorgiou, 2007).

In conclusion, there is evidence in the literature that drama can successfully be a useful approach when teaching science. A variety of drama techniques with some alterations to suit the age and experiences can also be applied for the teaching of early years science (Avdi & Hatzigeorgiou, 2007). However, there is a lack of research in relation to the use of drama for the teaching of early years science. This article describes the deployment of drama in delivering science. In particular, this paper will examine its use with early years children.

Methods

This article is based on a small case study that employed the implementation of an intervention lesson designed by the teachers/researchers and the use of pre- and post- semi-structured interviews. The sample comprised six children between four and five years of age attending a private pre-primary school in Cyprus. The researchers chose a typical urban school and the children attending could be considered as a small but representative sample in terms of the range of early years children in Cyprus[1]. After the identification of the specific school, the Headteacher was approached for permission for the school's participation. Next, a letter was sent to parents/guardians informing them about the purpose of the study and asking permission for their children's participation. Due to lack of time only six children were selected for the interviews. Even though the number of boys and girls that would participate was not an issue as gender was not one of the focuses of this study, we chose to focus on three boys and three girls.

The children were interviewed to identify their understanding and ideas relating to the water cycle phenomenon prior to and after the lesson intervention. Using direct questions to ask children about what they know is an obvious shortcut (Schmidt, 1997; Treagust, 1988) and thus it was very helpful to use such questions for the pre- and post-interviews. This type of question also helped in making a comparison of children's answers before and after the lessons. After obtaining permission from the participants and their parents, the three girls and three boys were interviewed and the conversations were audio-recorded. The pre- and post-interviews with the children were designed to be semi-structured to allow flexibility during the discussions. The children were interviewed individually by both researchers in a familiar, quiet and relaxed area of the school. The children had to answer the

[1] A normal Cypriot early years classroom would consist of no more than 25 children and approximately the same number of boys and girls coming from a middle socio-economic background.

same questions, either in a different order or with additional sub-questions, to further investigate their understanding. The recordings of the interviews helped to protect the authenticity of the data and cross-check the evidence, which avoided inaccuracy or incompletion (Robson, 2002).

The children were interviewed an hour before the lesson intervention and a day later. Each interview lasted approximately 15-20 minutes. The aim was to compare the children's answers from the pre- and post-interviews and investigate whether the lesson intervention had helped the children to further construct their initial ideas and improve their use of vocabulary when talking about the water cycle. In addition, the teacher who was delivering the lesson wrote a reflective note immediately after the completion of the lesson. This enabled the researchers to recall the process and further examine the children's engagement and reaction to the specific techniques (Basit, 2012).

The lesson intervention

The lesson intervention was developed by the two researchers based on the existing literature review for drama techniques and on children's age and previous drama and science experience. The lesson was video-recorded to enable the researchers to go back and reflect on the whole process. Permission from all parents to video-record the lesson and to take photographs was granted in advance. The aim of the intervention was for the children to be able to: a) represent the water cycle (journey of a water drop) by drawing, acting or describing; b) improve their initial understanding of the water cycle; and c) improve their use of vocabulary related to the water cycle phenomenon (e.g. 'steam', 'evaporation', 'water').

The lesson intervention began with the drama technique known as 'the teacher in role'; this technique enables the teacher to participate in drama by taking on a role, and through that role to narrate a story from that role's point of view (Dodwell, 2009). The teacher entered the classroom wearing a blue cloth around her. She took on the role of a water drop and begun to tell the story of the journey that a water drop follows; she presented the story from the water drop's point of view. While the teacher was narrating her (the water drop's) story, she displayed a representation of the water cycle as an aid to the story she was telling.

During the next activity, the teacher continued to be in role and asked the children to answer specific questions in relation to the story. The teacher asked questions such as: '*What do you think happens to water when it's very hot? What happened to the water drop in the story during her journey (e.g. when she was in the river, when she was in the sea, when she was in the cloud)? Where will the water drop go afterwards (after the river, after the sea, after the cloud)? What will happen to the clouds when they get cold?*' The teacher gave the children time to use their imagination and reply to each one of the above questions.

The following activity used the 'hot seating' technique. During hot seating, a character in a story is seated and questioned by the rest of the drama participants (Neelands & Goode, 2000). The specific activity involved different children who were seated in the middle and took on different roles. The rest of the children asked each one of the children seated on the 'hot chair' different questions. In this particular activity, the children took on several different roles according to the story that they heard, such as the Sun, clouds, a mountain and a water drop.

The next step was based on the 'mime' technique; during this activity, the children acted out the story that they heard through movements. This particular technique concentrated on movements and generally on the use of the body, instead of dialogue and spoken words (Neelands & Goode, 2000). Since the specific children had no previous experience of learning through drama, it was important to break down the mimed activity into steps. Firstly, the children were asked how they imagined that the characters of the story would move; for instance, how water runs through trees, or how a tree moves. After deciding on the movement of each character and scene of the story, children were split into two groups. One represented the story with movements during which the other group narrated the story to them, and then the two groups switched places.

When the two groups completed their presentation, a discussion followed regarding the context of the presentation and not how well they performed or acted out the drama technique in mime. The aim was to discuss the water cycle phenomenon and revise the different stages of this phenomenon. The children were finally given time to express their understanding of the water cycle on paper. During this final activity, both teachers were moving around the classroom discussing with children and helping them to find a way to express their thoughts and understandings. Some of the children decided to use arrows to demonstrate the series of events taking place during the water cycle.

Results and discussion

The main data were collected during the pre- and post-interviews conducted with the six children. The interview recordings were then transcribed by both researchers and notes on the differences in relation to each child's responses before and after the intervention were made. An initial descriptive analysis was completed by reading through the transcripts and making sense of the data. Then, a more interpretative analysis was completed during which similarities or norms were identified between different children's answers, with an attempt to see if there was any correlation with children's age, gender and engagement during the lesson.

The analysis of the pre-interviews suggests that the children held a number of initial ideas regarding the concept of the water cycle before the lesson intervention. During the pre-interviews, the researchers presented two pictures, one of which was showing a rainy day and the second a cloudy sky. The children were asked to describe the pictures as well as answer to specific questions in reference to the water cycle, such as '*Where does the rain come/fall from?*, *What is rain?*, *Why do you think that it rains?*, *Where do clouds come from?*, *Is there anything inside a cloud? If yes, what is there inside a cloud?'.* The children seemed to have particular difficulties in defining how clouds are created; for instance, they would state that *'God makes clouds with cotton'* (John, aged 5), *'From the wind'* (Andrew, aged 4.5), or even *'From the cloud machine'* (Amy, aged 4). Moreover, when the children were asked *'Where do you think that rain comes from?'*, they either remained silent or said that they didn't know. Only one of the boys, Andrew (aged 4.5), said that *'Rain comes from the clouds'*, but he seemed unable to explain this further.

On the other hand, during the post-interviews the children appeared to be more able to illustrate additional explanations and details concerning the water cycle in comparison to the pre-interviews. This was evidence based on the responses they gave to the same questions and also based on their explanations deriving from their drawings. Specifically, during the post-interviews the children were asked to describe the drawings they made the previous day, during the last activity of the lesson intervention. During this process, two particular children provided a very accurate description of the water cycle based on their drawings, a summary of which is provided here:
'Raindrops fall from clouds in the sky. They drop in the sea and in the rivers and everywhere. Then the sun heats the water drops and makes them vaporise and they go up in the sky and make clouds. And then they get cold and become grey and start raining again' (Anna, aged 4).

'This is the cloud that rains [showing a cloud in his drawing]. *The water drops fall into the rivers and the sea and the trees. Then the sun heats the water in the sea and they get very very hot and they vaporise and they go back to the clouds. Then in winter the clouds get cold and it rains'* (John, aged 5).

A comparison of the children's descriptions before and after the intervention indicates a positive effect on the use of vocabulary relating to the water cycle. It also indicates an improvement in their understanding of the specific topic. All six children were able to provide an improved description of the phenomenon after the lesson intervention, something which suggests that their understanding was developed. Furthermore, when comparing the answers given by the children in the pre- and post-interviews in relation to the pictures that were shown to them, significant improvement was shown concerning their explanations of what rain is and where it comes from and also what clouds are made of and how they are created. The following shows Mary's (aged 4.5) responses during the pre- and post-interview as an example:

Pre-interview:
Researcher: (First picture) What do you see?
Mary: Clouds.
Researcher: Can you explain what a cloud is?
Mary: No. They are up in the sky. The sky made them.
Researcher: What do you think that clouds are made from?
Mary: I don't know.
Researcher: Do you think that there is something in the clouds?
Mary: Yes.
Researcher: What?
Mary: I don't know.
Researcher: (Second picture) What do you see here?
Mary: Rain. There is water.
Researcher: Can you explain what rain is?
Mary: No.
Researcher: Where does it come from?
Mary: I don't know.
Researcher: Do you know why it rains?
Mary: Because God brings it.

Post-interview:
Researcher: (First picture) What do you see?
Mary: I see rain.
Researcher: How can you tell that it's rain?
Mary: I can see the water drops.
Researcher: (Second picture) What can you see in this picture?
Mary: I can see clouds.
Researcher: Do they have something inside?
Mary: Rain… va… vapor.

The above quote demonstrates that this particular child could not completely describe or indicate the origin of clouds and rain during the pre-interview, whereas we can observe that there is a positive change in her responses during the post-interview. The comparison in this case, as well as those of the other children, suggests that children's post-interview answers are more accurate than the ones given during the pre-interviews and there is a notable improvement in the use of proper vocabulary relevant to the water cycle.

Overall, based on the interviews, five out of the six children benefited from the lesson, which might indicate that most of the children who participated in the lesson benefited in relation to their learning of science and specifically in relation to the use of vocabulary. It is important to acknowledge the significant improvement of vocabulary, since drama has been indicated to benefit children's vocabulary development. The fact that the 'teacher in role' technique was applied along with a narration is something which amplifies the idea that telling stories can have a positive effect on children's language development (Ellis & Brewster, 1991; Grainger, 2005). This indication points out that combining drama techniques in science lessons can enable children to gain access to science terms and vocabulary in a more creative and active way. This can also help children improve their understanding of scientific phenomena.

Even though the specific results cannot be generalised due to the limited number of participants and the small scale of the research, it is important to acknowledge that they indicate that drama techniques can have a positive impact on children's learning of science and can help children to comprehend and recall specific words. However, the fact that children's vocabulary concerning the topic of the water cycle was improved cannot guarantee that their understanding of the water cycle phenomenon was improved as well or that these results will last. This does not suggest that other techniques cannot be successful as well. It does however stress the positive impact of drama as well as its capacity as a creative and innovative approach when teaching science (Metcalfe *et al*, 1984; Varelas *et al*, 2010).

Implications for the early years

This study employed drama techniques in teaching a specific science topic. The particular intervention is a lesson that can be considered as a creative one, since it combines innovative activities that are not usually applied when teaching science. One of the main experiences that this lesson offered to the children is that of seeing the curriculum subject of science through a different lens. As Yoon (2006) highlighted, science drama may enable children to talk, express, adapt and evaluate their knowledge and thoughts. By entering roles, like the drama technique of hot seating, children can experience the meaning of a context from a different perspective and at a different level. Different drama techniques can be used for the teaching of other topics as well. As Ødegaard (2003) argued, drama enables children to process and stretch their metacognition through empathy.

Although the techniques described above were applied for the teaching of the water cycle, this does not mean that the children have taken all the experiences that the chapter of the water cycle has to offer them. The above lesson should be considered as an initial lesson regarding the water cycle and part of a unit of lessons on the specific topic. For instance, children could be given different scenarios and asked to act out, with the use of the drama technique known as 'small-group-playing', scenarios that introduce experiments.

Experimentation in science is an essential aspect, thus it would be useful for teachers to continue with a follow-up lesson that would explain experiments and include inquiry-based and hands-on activities as well. A third lesson could include more science-drama techniques such as still images, live images, thought-tracking or dramatisation (Neelands, 2002; Grainger, 2003).

This study demonstrates the importance of the teacher's role regarding children's learning and teaching. Teachers should seek out opportunities to be creative and innovative when it comes to their teaching and consequently children's learning (Grainger, 2003) and to look at a range of approaches to support learning. Drama can offer this creative approach and benefit children's cognitive, emotional, kinaesthetic and social development (Smith, 1983; Sergi, 1991; Rubin & Merrion, 1996). The positive outcomes that drama has to offer can be applied across the curriculum, as well as in science.

Conclusion

The results of this small-scale study indicate that the application of drama techniques for the teaching of science can have a positive effect on children's construction of scientific knowledge, at least as far as vocabulary is concerned. It is essential to point out that the purpose of using drama techniques for the teaching of science should not be for the children to act out correctly and efficiently the drama techniques, but to enable them to develop their understanding of the topic under investigation.

Drama should be seen as a creative approach and an aid for teaching young children (Rubin & Merrion, 1996; Goldberg, 1997). The opportunities and experiences that drama has to offer to children and to teachers can give access to new aspects of knowledge and understanding (Grainger, 2003). The variety of opportunities that drama offers is what makes it a valuable and creative means for teaching a range of curriculum subjects (Baldwin, 2008).

Teachers can introduce drama to complement their teaching, as it can help to provide opportunities to see what children know and think in different and more accessible ways (Yoon, 2006).

This is an initial exploration of the advantages of using drama to support young children's learning when teaching early years science. Further attempts should continue to be developed until we have a better understanding of how drama can be employed when teaching science in the early years and how it builds on, supports or enhances learning. Future work should gather evidence on a larger scale to improve our knowledge of how drama can help to support and develop children's scientific understanding, as well as ways in which it can be used to increase children's engagement, enthusiasm and motivation for learning science.

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Extended Abstracts I: ICASE World Science Conference 2013

Introduction

Sue Dale Tunnicliffe

The following two papers were first presented at the ICASE World Conference held in Kuching in September 2013. The next ICASE World Conference will be held in Natalya, Turkey, in September 2016. ICASE is the International Council of Associations for Science Education, an organisation for educational associations and organisations connected with science learning, who join as Associate members. It is not an individual membership organisation.

Further details can be found on the website: www.icaseonline.net

ICASE seeks to encourage the dissemination of effective practice in the learning and teaching of science, in formal education from the earliest years and in out-of-school and family learning situations, which can be anywhere or in facilities such as zoos, botanical gardens, science centres and museums. Over the past 40 years, over 200 organisations have been members of ICASE.

The first paper, from Nigeria, explains how a Department of Integrated Science at a state college of education in Nigeria seeks to show teachers in training how science does not stand alone, but is integrated in mathematics and through hands-on activities in science and in technology. What is clear is that students need to communicate and collaborate, which enhances interpersonal skills and literacy prowess. Indeed, many young people will write and communicate effectively when they have something meaningful about which to communicate! This interesting paper discusses how the authors introduced basic science and technology through the ASEI-PDSI approach (Activity, Student-centred, Experiments and Improvisation – Plan, Do, See and Improve).

From the other side of the world, colleagues from São Paulo in Brazil discuss their study that analyses activities carried out throughout 2010 by a class comprising 18 first grade students (5-6 years of age) learning in a Brazilian elementary school. The study focused on the allocation of scientific meanings, by young children, occurring through a combination of the three systems of representation proposed by Bruner in 1973: iconic, enactive and symbolic. The article also emphasises the central role of the teacher in the development of scientific meanings in young learners.

Both these papers address issues that are of global concern, even if not yet implemented because of curricular and assessment constraints on many schools in many countries where children are being tested solely for factual recall. However, the tide seems to be turning, with PISA stating that, in future, the skills behind problem-solving ability will be tested.

Extended Abstracts I (i)

Effective teaching and learning of basic science and technology through an ASEI-PDSI approach

■ Emmanuel O. Emeji

Abstract

ASEI-PDSI is an acronym for Activity, Student-centred, Experiments and Improvisation – Plan, Do, See and Improve, developed as a teaching approach for the SMASE Nigeria project. The approach is considered to be significant in the teaching and learning of basic science and technology in primary schools. It is not a new method, rather an innovation in strategy that emphasises activity-based, learner-centred and participatory teaching and learning processes. The article enumerates the features of the ASEI-PDSI approach, ASEI lesson plans and points to consider when preparing and implementing ASEI lessons. The merits of the approach, challenges and how to manage these challenges to enhance teachers' and pupils' performance in basic science and technology are discussed.

Introduction

An activity-based, learner-centred and participatory approach, which takes care of the shortcomings of age-long classroom practices, is needed to improve the teaching and learning of basic science and technology in our primary schools. To enrich our classroom practice with the intended learning outcomes, the ASEI-PDSI approach is advocated (SMASE, 2006).

Teaching basic science and technology following traditional methods or practices in which lectures or discussion are often used has been proved to have led to the poor performance of pupils in mathematics and science subjects (SMASE, 2006). Knowledge is dynamic and teachers must be dynamic too in order to keep abreast of innovations in the profession. According to Emeji and Enekwe (2009), there has been a shift in emphasis from passivity to activity on the part of the child in education throughout the world. Children under 9 years of age are curious, inquisitive and anxious to explore their environment. Opportunities need to be provided to activate the knowledge in them through the carrying out of activities during teaching and learning of science and technology.

The abstract nature of some concepts makes the subject difficult for both teachers and pupils. This needs to be tackled with a teaching approach that clears doubts and makes scientific facts discoveries rather than giving instruction. The minds-on and hands-on nature of ASEI lessons is highly significant in improving the learning of science and technology, especially for children from 0 to 8 years of age. The principles and merits of the approach will provide meaningful information and make for better teaching and learning.

The best-known theory of cognitive development was developed by Jean Piaget, who became interested in how children think and construct their own knowledge (Thomson, 2009). Piaget asserted that human intelligence develops in stages, each of which enhances a person's understanding of the world in a new and more complex way. He believed that children, by exploring their environment, create their own cognitive or intellectual conceptions of reality. By continually interacting with their environment, they keep adding to and reshaping their conceptions of the world. This occurs not through direct instruction but rather through the child's own mental activity and internal motivation to understand (Thomson, 2009).

Principles of ASEI, like the Basic Science curriculum that is in use in Nigeria in upper basic secondary schools, have inbuilt strategies where learners are required to be involved in inquiry and related activities that can develop critical thinking skills.

This is seen in the objectives of the New Basic Science Curriculum (NERDC, 2007), which includes enabling students to:

- Develop an interest in science and technology;
- Acquire basic skills in science and technology;
- Apply their scientific and technological knowledge and skills to meet societal needs;
- Take advantage of the career opportunities offered by science and technology; and
- Become prepared for future studies in science and technology.

ASEI as an intervention strategy takes cognisance of how pupils learn. Pupils do not simply copy the science world; rather they construct their own meanings around it. They must be provided with the opportunity to construct scientific knowledge through the interaction of their observation, prior knowledge and mental processes.

ASEI lesson plan format

General information

- Date, duration, topic, class, age, etc.
- Learning objectives.
- Rationale (importance of the topic to the pupil's daily life).
- Prerequisite/previous knowledge.
- Learning materials.

What to do when planning an ASEI lesson

The fact that the teacher should guide the learners to acquire and explain the most important points and concepts of the lesson should be reflected in the planning (Duquette, 1997; Alsop & Hick, 2001), thus:

- Set the objectives of the lesson, capturing what the learners can/cannot do;
- Take into account learners' backgrounds, such as age, learning difficulties, their needs/interests/misconceptions, growth of experimental skills and previous experience in relation to the topic;
- Choose and prepare the appropriate adequate teaching materials and activities based on the lesson objectives;
- Produce and/or prepare improvised materials for practical work, which help to achieve the objectives;
- Select and combine learning styles or teaching methods that are appropriate for each step of the lesson to realise the objectives of the lesson; and
- Plan for black/white board use and how the learners will copy the notes into their notebooks.

Lesson development

When introducing the lesson, incorporate the previous knowledge/skills/everyday experience of learners, link them to the new topic and clarify what the teacher wants the learners to learn. Stimulate the learners enough to arouse their interest and curiosity. Devise means of making learners ask questions and accept how they start.

In developing the lesson (grouping/group work), encourage learners to express their prior experiences, explain their ideas related to the content, give their own hypotheses/predictions and discuss how these differ from those held by others. Encourage learners to offer their own observations/results of the activity and to discuss how they differ from those of others. Encourage the active participation of learners in the main teaching steps. Evaluate the lesson, supervise class/group work, and check the accuracy, correctness,

Lesson development: (SMASE, 2006)

Stage/Time	Teacher's support	Learner's activity	Learning point
Step 1: **Introduction** (? mins) – full class	State what the teacher would say or do	State the response or action the learners should take	State the point or skill intended to be learnt corresponding to the activities done
Step 2: **Group formation** (? mins)	"	"	"
Step 3: **Group work** (? mins)	"	"	"
Step 4: **Harmonisation** (? mins) – full class	"	"	"
Step 5: **Evaluation and conclusion** (? mins)	"	"	"

depth and appropriateness of the content through questions and answer techniques. Ensure that slow learners understand the content.

Conclude the lesson by reflecting on the set objectives, clarify what needs to be summarised about the lesson and encourage learners to draw conclusions (SMASE, 2006).

Challenges of the ASEI-PDSI approach

- Teacher's workload is increased.
- A great deal of time is required for planning.
- Syllabus coverage is hardly attainable.
- Funding constraints.
- Resistance by teachers to the new approach.

Managing these challenges

- Proper storage and timely maintenance of materials.
- Consistent practice.
- Sensitising curriculum developers and other stakeholders.
- Improvisation.
- Appreciate the need to develop a positive attitude to the teaching and learning of basic science and technology.

Merits of the ASEI-PDSI approach

The application of ASEI lessons in the teaching and learning of basic science and technology gives room for pupils' active participation. It generates and sustains pupils' interest and makes the teacher a facilitator of the learning process. It helps the teacher prepare well to meet any challenges and use locally made materials to attain the learning objectives. The approach arouses curiosity, and increases understanding, retention and application of scientific concepts in real life experiences. It develops cognitive and affective skills (minds-on activities), psychomotor skills (hands-on activities) and process skills such as observation, record keeping, analysis and interpretation of data. The approach takes care of the needs of pupils' individual differences and encourages knowledge discovery by the pupils.

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Extended Abstracts I (ii)

The systems of representation in early science education

■ Maria Helena Blasbalg ■ Agnaldo Arroio

Abstract

Based on a qualitative research design, this study revolves around the analysis of activities accomplished throughout 2010 by a class comprised of 18 first grade students at a Brazilian elementary school (ages 5-6). An interdisciplinary project entitled 'Solar System' was developed, which aimed at understanding how children in this specific age group construct their meanings on scientific culture. Data collection included different activities in order to consider the three systems of representation proposed by Bruner (1973) on the child's cognitive development (iconic, enactive and symbolic representations). The results suggested that the allocation of scientific meanings by children occurs through the combination of the three systems of representation, both among formal teaching situations and in other moments of their everyday lives. The results emphasise the teacher's central role during the development of scientific meanings; it is up to her to organise the learning environment, providing children with opportunities to experience scientific phenomena as well as to build representations about subjects related to science.

Introduction

Although many researchers point towards the important role of science education in children's development (Carvalho, 2004, 2007; Sasseron & Carvalho, 2007; Dewey, 1897; Bruner, 1973; Vega, 2006; Deighton, Morrice & Overton, 2011; Johnston, 2005, 2011; Harlen & Rivkin, 2000; Capecchi & Carvalho, 2006), how to integrate it in their schooling still represents a complex challenge for teachers (Monteiro & Teixeira, 2004; Fourez, 2003; Jiménez-Aleixandre, Rodrigues & Duschl, 2000; Driver & Newton, 1997).

To better understand the process of concept attainment (Bruner, 1973), this article, based on a socio-cultural perspective of science education (Driver, Asoko, Leach, Mortimer & Scott, 1994; Lemke, 1990; Carvalho, 2008), aims to discuss the assignment of scientific meanings in the early years of schooling, through the development of different systems of representation in which children are able to go beyond the information that is given to them (Bruner, 1973).

Considering these ideas, proposals concerning the teaching and learning of science should be planned and designed in order to instil contemplative action in students, encourage reproduction through drawings, observation, reflection, exploration and manipulation and, finally, search for explanations and verbalisation of concepts validated by the scientific society. These activities should provide children with new scientific experiences (Dewey, 1897) by not only exploring the world around them but also constructing representations about such experiences (Bruner, 1973) and thus solving their everyday life issues (Johnston, 2005; Vega, 2006).

The socio-cultural approach of science education in early years of schooling

The socio-cultural approach of science education is based on Vygotsky's assumptions. According to him, the construction of meaning is always related to the presence of others and mediated by tools constituted by culture (Vygotsky, 1962). This approach seeks to make a close relationship between science/technology/society, and understands science as a culture that holds rules, languages and values of its own (Driver *et al*, 1994; Lemke, 1990; Carvalho, 2008).

This concept presupposes the idea that science education is more than a mere group of specific content, but that it also includes the construction process of scientific culture (Carvalho, 2005). Under this perspective, scientific knowledge is a social construct, validated and communicated socially, whose learning involves the acquisition of cultural tools and techniques that can enable children to understand and act in the world through the lens of scientific culture. Such assumption implies not only understanding of scientific concepts, but also the development of attitudes and abilities related to them (Johnston, 2011).

It is important to stress that language assumes a central role in the learning process under this focus (Driver *et al*, 1994; Lemke, 1998; Candela, 1999), as it involves the way in which scientific meanings are constructed (Yore, Bisanz & Hand, 2003). In addition, language (oral and written) is the symbolic system most used by scientists to organise, describe and present the claims and arguments related to science culture. However, in order to do science and talk, write and read about science, it is necessary to combine, in different ways, canonical verbal discourse, mathematical expression, graphic representation and visual-motor operations (Lemke, 1998). For Lemke (1998), the teaching and learning of science includes the study of all modes of signification that people employ in scientific forms of human activity.

Jerome Bruner was a great supporter of early science education. He stressed that the systematic teaching of elementary notions of science and mathematics in early years can provide a better understanding of certain concepts that are worked with in later years. His research on the growth of the human intellect has made many important contributions to understanding the process of constructing knowledge in the children's early years.

Bruner (1973) recognises that humans, in developing the intellect, use techniques and technologies of information coding and processing by which it is possible to conserve aspects from the world or segments of past experiences, recovering, when necessary, relevant information in order to achieve higher than the temporary information. These technologies are transmitted to children by agents of the culture that are responsible for teaching ways of responding, looking and imagining, and ways of translating experiences into language. The end product of such a system of coding and processing is what Bruner deems a 'representation'. According to Bruner, (1973, p.316) *'representation or a system of representation is a set of rules in terms of which one conserves one's encounters with events'.*

Depending on their nature, these systems are called: *enactive representation*, *iconic representation* and *symbolic representation*. This means that people can represent some events by the actions they require, by some form of picture or image, words or other symbols.

Bruner (1973, p.328) denotes:
'Enactive representation… a mode of representing past events or segments of the environment through appropriate motor response (such as bicycle riding, tying knots, aspects of driving). Iconic representation summarizes events by the selective organization of percepts and images, by the spatial, temporal, and qualitative structures of the perceptual field and their transformed images. (…) Finally, a symbol system represents things by design features that include remoteness and arbitrariness'.

In effect, the representation of an event is selective, usually '*determined by the ends to which a representation is put – what we are going to do with what has been retained in this ordered way'* (Bruner, 1973, p.316). In a child's life, the enactive representation is the first kind to appear. The second kind is the iconic representation and lastly the symbolic – each depending upon the previous one for development. Based on these ideas, growth does not involve a series of stages but rather consists of a progressive mastering of each system and its transition from one representational system to another.

The growing child begins with a strong reliance upon learned action patterns to represent the word around him. In time, there is added to this technology a means for simultanising regularities in experience into images that stand for events in the way that pictures do. To this is finally added a technology of translating experience into a symbol that can be operated upon by rules of transformation that greatly increase the possible range of problem-solving (Bruner, 1973, p.345).

In children between the ages of 4 and 12, language comes to play an increasingly important role as an instrument of knowing. Translation of experience into a symbolic form opens up intellectual possibility that overcomes the most powerful iconic system.

Dewey (1897) also stressed the importance of early science education. Pursuant to him, the study of science is especially valuable once it allows children to develop the ability to construe and control their past experiences. In this process, the teacher has to use the children's everyday life experiences in order to gradually (by extracting the facts and rules therein) take them to scientific experiences. As a consequence, the subject matter emerges naturally from the activities, through thinking, or from the children´s own suffering – something that cannot be designed or generated meaninglessly.

In agreement with Dewey's ideas, Johnston (2005) emphasises the importance of scientific experiences in the early years and highlights that the quality of such experiences is related to their physical, emotional, cognitive, social and linguistic development. In fact, exploration is an important part of the learning process, and it is necessary to provide children with opportunities to explore a large variety of resources during the attribution of meanings process.

Assuming that the attribution of scientific meanings develops as the children explore the world around them and experience the scientific phenomena, it is necessary to offer students the widest possible variety of resources to explore (Johnston, 2005; 2011), encouraging social interaction and ludic handling of material selected by the school (Vega, 2006). Through the experience, children can check and verify the operation of the things, the cause and effect they produce, correlating past experiences into new combinations (Vygotsky, 2003). The knowledge developed in this way expresses the child's initial attempts to construct scientific concepts, which, although quite intuitive, demonstrates their initial reflections.

Since *'experimentation is the fundamental basis of the entire discovery and one of the keys that open the doors of knowledge'* (Vega, 2006, p.17), early science education should promote experiences to children that enable them to be in contact with the scientific culture from the interaction and handling of different resources. By using their hands, the young children can discover the main characteristics of these materials and also store new experiences. Such experiences provide children with the opportunity to check and verify the operation of things, and the cause and effect they produce. After checking the effect of such actions several times, children begin to build hypotheses, make their first deductions and re-elaborate the obtained information by consolidating their learning over scientific concepts.

Based on these ideas, we believe that scientific culture, one of the many cultures that our society has produced, should be presented to students by the school without the intention of training future scientists, but instead to instigate curiosity and aid in developing scientific views about everyday life phenomena, with the goal of preparing them to be citizens capable of acting consciously in the world around them. For this purpose, it is necessary to provide children with opportunities to discuss topics related to aspects of scientific culture present in their everyday lives, as well as opportunities to recreate them through different systems of representation.

Methodology

This present research involved a class comprising 18 children (from the ages of 5 to 6 throughout the 2010 school year) from the first grade of elementary education in a Brazilian private school. Considering the assumptions of a socio-cultural perspective on science education, the theme 'Solar System' has been systematically studied during the school year through an interdisciplinary project originated from and based on the concern of the group (Blasbalg & Arroio, 2013). The project assignments, besides offering opportunities for children to make decisions and choices regarding the work to be done, also provide them with a collaborative problem-solving activity where a co-operative inquiry occurs between the children and adults, providing a stimulating, discussion-based learning environment. The work is nurtured by an emergent curriculum, which is structured around the students' own interests or needs (Edwards, Gandini & Forman, 1995).

Having considered the context of the research development imperative to the study, a qualitative research (Bogdan & Biklen, 2003) was elected. Based on this design, data were collected in order to contemplate the three systems of representation proposed by Bruner (1973), and used by children during both the formal teaching activities as well as in other first grade contexts, such as school breaks and free time.

The enactive representations were obtained through photographs and notes recorded in a field notebook. The iconic representations were acquired through drawings designed by the children with the aim of recording and systematising the themes studied during the project (ranging from free time drawings and drawings from other activities). Lastly, the symbolic representations were gathered using circle time filming and its transcription, through collective texts designed to organise the studied ideas, and through interviews with the researcher.

Findings

During this study, we verified that children used the three systems of representation proposed by Bruner (1973) in constructing meanings about their scientific experiences. Children sometimes use their own bodies, sometimes mental figures, or language, to create meanings about the phenomena of their interest. Actually, on many occasions we observed the concomitant use of the three systems of representation in the construction of the scientific concepts and their respective transposition from one system of representation to another.

The enactive representations were observed by handling the material available in the classroom, such as an overhead projector, photographs and scientific culture books, in make-believe plays, drama and during playtime. On these occasions, it was possible to realise that children use their own bodies to better understanding some concepts related to the scientific culture, such as handling materials or making movements and gestures.

The iconic representations were the most frequently used by children during the school day. Such representations, basically composed of drawings, were observed not only during the Solar System Project but also during other daily activities and playtime.

The circle time and interviews took a central role in the construction of symbolic representations about scientific themes studied. These practices allowed for reflection and the construction of explanations during the process of world re-signification.

Enactive representations produced by playing with the overhead projector

Manipulation of the overhead projector was much appreciated by the group. The use of the projector enabled children to become familiar with images belonging to scientific culture, to build their hypotheses on the formation of such images and simultaneously reproduce them in play or make-believe themes studied during the project work.

Figure 1: Exploring the overhead projector

Figure 2: Exploring scientific pictures on the overhead projector.

Figure 3: A student pretending to be teacher.

Figure 4: Playing with scientific images on the overhead projector

Figure 5: Image of Earth and rocket made of paper, during play.

Initially, children seemed quite shy when handling the equipment. As the apparatus became more familiar, they began playing make-believe and testing new possibilities for constructing the images.

Figure 6: Reproducing the craters of mercury

Construction of enactive representations by playing in the sand pit

When studying the main features of Mercury, children showed great interest in the craters on the surface of this planet. In view of this, a discussion about how craters are formed was started and the group was given the challenge of 'making' some craters in the sand pit. At the beginning of the experiment, children launched into the sand any kind of object. After a while, they realised that the printouts obtained did not have the same shape as the craters of Mercury. From that moment, they began to select the most suitable objects and, finally, they found that balls produce prints that look more like those observed in class.

Iconic representations: records and free time drawings

During the project, the use of iconic representations of the topics studied in the classroom proved to be quite frequent. Indeed, these representations were present at different times, such as during the games and activities related to literacy, revealing connections between the concepts studied and scientific aspects of the child's universe.

Figure 7: Children drawing on the class blackboard during free time.

The analysis of graphic records seemed to indicate that children select the aspects that will represent their focal interest or needs, as well as establish personal relationships with the object of study. According to Bruner (1973), the representation of an event has a synthetic nature that is not an arbitrary or random sample, but rather always done in a selective manner – determined by what is proposed to be represented.

Figure 8: A birthday card made for a classmate. (The 'V' means Venus, 'L' means Moon, 'S' means Sun and 'T' means Earth)

Figure 9: Record of Jupiter made by MR: *'Jupiter has a hurricane called red spot; it has 63 moons and an almost invisible ring'.* (Moons (LUAS); a very fine ring (UM ANEL MUITO FININHO); my friends (MEUS AMIGOS)).

Symbolic representations: circle time and interviews

The 'conversation circles' are quite familiar to the first grade children and appropriate to this research, even though the primary focus is written language.

From this perspective, discursive practices aim to give children an opportunity to express themselves orally, to express their opinions and communicate their thoughts. These occasions, mediated by an adult, favour the development of discursive abilities to expose, report, explain and argue.

Therefore, they are especially relevant in science education, since they enable children to develop explanations of scientific knowledge claims and some aspects related to scientific culture, thus providing the children with a better understanding of the world in which they live (Sasseron & Carvalho, 2007).

Along with this research, conversation circles occurred during or after the reading of texts and materials brought in by students. The following transcript (Table 1 overleaf) is part of the discussion around the planet Mars, which occurred during the reading of the two books chosen to support the project. (To preserve their identity, students are identified by letters.)

Important aspects of science education observed from the circles of conversation included the natural acquisition of the terms belonging to scientific culture (Carvalho, 2007). It was found that children expressed their ideas spontaneously using the concepts studied in past activities, such as 'craters', 'satellite', 'Olympus Mons' and 'Great Red Spot'.

At turn 76, the comment by EF, *'Is not true'*, expresses his opinion about the veracity of the image used in the activity. This example shows a concern with the process of building science and highlights an important aspect of science education from a socio-cultural perspective (Carvalho, 2005). In this same discussion, the relationship between science/technology/society was another aspect observed. In turn 66, the student GC asks *'Hubble takes pictures, doesn't it?'* to check the veracity of Saturn's picture, revealing that he already knew about the Hubble telescope and its function.

In turn 90, the almost automatic response given by the children when the teacher asked if there is a Moon during the day showed the spontaneous formulation of a concept on this subject. According to Vygotsky (1962), in their spontaneous concepts, children have difficulty in verbally formulating the concept, using it arbitrarily and in establishing logical relations with other concepts.

On many occasions, children used gestures, handling or body movements to supplement their oral explanations. The combined use of symbolic, enactive and iconic representations was quite evident during interviews in which children could consult their records about the discoveries made during the project. It is important to clarify that this record book consisted of drawings, explanations and models of the planets studied.

The transcription (Table 2, page 26) shows that EF needed the support of the images from his record book to be able to express what he learned about the Solar System.

Table 1: Discussion around the planet Mars

Turn (order of) talking	Talk transcription (symbolic representation)	Gestures (Enactive representation)
	Teacher begins the activity by recapping what has been already studied. She shows the picture of Mars on the overhead projector.	
45	MM: It's Mars!	
46	Teacher: Yes, it is. Mars is reddish. What is this? (She points to the polar ice cap)	
47	GC: Water.	
48	RC: Ice.	
49	Teacher: And what is this?	
50	MM: Great Red Spot.	
51	Teacher: It isn't the Great Red Spot. It is something else.	
52	RC: A volcano.	
53	Teacher: Yes, it is.	
54	RC: It is the Olympus Mons.	
55	Teacher: That's right. Leaving Mars, towards the fifth planet... (She shows a picture of Jupiter)	
56	LS: Jupiter!	
57	Teacher: That's right! The giant planet. What is this image?	
58	EF: It is the Great Red Spot.	
59	Teacher: And now, we will see...	
60	LS: Saturn.	
61	Teacher: Very good! (She shows a report containing a photo of Saturn on the overhead projector)	
62	MS: Oh! It is beautiful!	
63	Teacher: I'm not sure (She reads the photo caption), but I think that image isn't a photo. I think it's a drawing. Saturn is far, and because of this it's hard to get pictures of it.	
64	RR: I can see a satellite.	
65	Teacher: Probably. It looks like a satellite	
66	GC: Hubble takes pictures, doesn't it?	
68	EF: We will see other planets too?	
69	Teacher: As we agreed, today we will study only Saturn.	
70	EF: Ah...	
71	IP: Only?	
72	Teacher: This is another picture of Saturn.	
73	BS: This one is beautiful.	
74	Teacher: In this picture, where is the Sun?	
75	BS: Right here.	She points to the left and makes a circle with her hands so mimicking the shape of the Sun
76	EF: Is not true. It is not. (Referring to the origin of the illustration)	
77	Teacher: RR will explain something.	
78	RR: The sun is over here.	He mimicks the sunshine shining on Saturn
79	Teacher: What happened to the other side of Saturn?	
80	RR: It has gotten dark.	
81	Teacher: What is this part right here?	She points to the dark part of Saturn's image.
82	MR: The other part of Saturn.	
87	MS: I think the Sun is on that side and the Moon is on this one.	He draws an imaginary circle with his forefinger to show the whole planet
88	Teacher: So, this side of the planet is in the clear and the other is in the dark ...	
89	MS: Because the Moon is on that side...	
90	Teacher: Is there a Moon during the day?	
91	Many children: No.	
92	LS: Yes, there is.	
93	Teacher: Has anyone seen the Moon during the day?	
94	LS:	He nods his head.
95	Many children: I've seen...	

Table 2: EF interview

Turn talking	Talk transcription (symbolic representation)	Gestures (Enactive representation)
1	RESEARCHER: Did you enjoy studying the Solar System?	
2	EF: Yes, I did.	
3	RESEARCHER: Why?	
4	EF: Because I like to learn.	
5	RESEARCHER: Tell me what you learned.	
6	EF: I didn't learn anything.	He begins moving in his chair.
7	RESEARCHER: Nothing?	
8	EF: Each planet appears in a way.	He opens his record book and begins to swipe his forefinger over the design of Mercury, making circular movements.
9	RESEARCHER: How so?	
10	EF: Some are smelly, some have a lot of little holes...	
11	RESEARCHER: Do you know what those little holes are?	
12	EF: They are craters.	
13	RESEARCHER: That's right. You said that some are smelly. Which planets were you talking about?	He nods his head.
14	EF: Venus.	
15	RESEARCHER: Do you want to say something else?	
16	EF: The Sun is a star. Jupiter is huge. That's all.	He shakes his head. He handles the pages of his book. He continues handling his book and terminates the interview.

Discussion

Assuming that science is part of a culture that includes specific language, values, practices, perceptions, theories, beliefs and materials – learning science means sharing the various aspects that make up this culture. To do this, it is necessary to provide children with opportunities to experience some aspects of scientific culture as well as to build representations on these experiences according to their focus of interest.

During this research, it was possible to notice that children sometimes use their own bodies, mental figures or language to create meanings for the phenomena of their interest (Bruner, 1973). This process is not restricted to the formal teaching moments and occurs constantly in different school contexts.

The enactive representations were observed by manipulating the material available in the classroom, such as projections, scientific culture books and images, during make-believe plays, drama and in the playground time. On these occasions, it was possible to realise that children use their own bodies to better understand some concepts related to the scientific culture or to complement their oral explanations and better communicate their thoughts (Bruner, 1973).

The use of the overhead projector highlights the importance of the action in building new concepts and in assigning meanings. It was noticed that children only made a few findings while they were simply observing the functioning of the equipment. The perception of the importance of the transparency in obtaining images only happened after handling the projector, manipulating and playing with the transparencies and testing new material.

The iconic representations, constituted by plastic works and drawings, were the most common kind observed. Actually, children commonly availed themselves of this type of representation to assign meanings to the topics studied in the classroom.

Data analysis also indicates that the children not only combine scientific concepts studied during the project according to their interests and concerns (Dewey, 1897), but also in different school contexts. These results support the studies of Vygotsky (2003) on the attribution of meaning process, in which children combine elements of their near reality with their past experiences, in order to establish new combinations, evidencing in those reorganised concepts the particularities of their own thinking. According to Vygotsky (2003), children construct knowledge through the subjective recreation of reality by integrating their individual characteristics or focus of interest. In fact, it was observed that children have incorporated into their findings many elements of their everyday lives, such as family members, friends, animals, plants and even the author of the work. The documents produced by them contain a meaning unique and personal to the theme studied. This fact is a very important aspect of the learning process, as it provides for the approach between children's spontaneous concepts and those validated by the scientific community.

The analysis of iconic records also showed that children incorporate the themes previously studied in other projects, beyond the issues of their everyday lives. The experiences generated by the first activities of the Solar System Project stimulated the reworking of following experiences, enriching and expanding the possibilities of assigning meanings.

Data analysis also points out the use of symbolic representations that were more difficult for this age group. In fact, most of the time children have their symbolic representations supported by using enactive representations, such as body movements, or by using iconic representations, such as the illustrations. In those situations the teacher's mediation was very important, not only to give the children the missing words, but also to help them organise their thoughts. According to Carvalho (2007), Lemke (1990) and Driver *et al* (1994), language assumes a central role in science education, and it is the teacher's role to create opportunities for children to construct explanations on topics related to science.

On the other hand, throughout the year, the new and 'difficult' words generated great interest in the children. Questions about their meanings were very common and the appropriation of terms and expressions belonging to the scientific culture, such as 'Moon', 'satellites' and 'rings', occurred quite naturally. However, it is important to clarify that the focus of science education is not to memorise words. Acquiring new terms is a very important aspect of science education, once it represents the beginning of the concepts' development (Vygotsky, 1962) and the transition from everyday life language to scientific language (Carvalho, 2007).

Conclusion

The spontaneous building of representations was observed not only in formal situations of teaching, but also during free and playground times. This indicates that the construction of scientific meanings is not restricted to the classroom, but rather occurs constantly in different contexts in children's lives. This reinforces the importance of teacher mediation in all contexts of school. The teacher ceases to play the role of a mere transmitter of concepts and becomes someone who can offer, to students, models of how scientists speak, write, build diagrams, calculate, plan, observe, represent and analyse data, formulate hypotheses and conclusions, and connect theories, models and information in the construction of scientific knowledge.

The results obtained during this research highlight the role of the teacher as the mediator in the process of acquiring scientific meanings, giving him/her the crucial task of organising properly the learning environment of the subjects related to science education. The teacher must offer the first grade students experiences that lead them to reflect on science issues and the consequences for their lives, providing them with opportunities to construct the scientific knowledge by using the three systems of representation – in other words, through images, manipulation of objects, body movements, and the use of oral and written language.

With this study, we hope to contribute to a better understanding of the possible ways to provide children with experiences that respect the way in which they construct meanings in that age group, and lead them to reflect on scientific subjects of their interest and the consequences of these on society.

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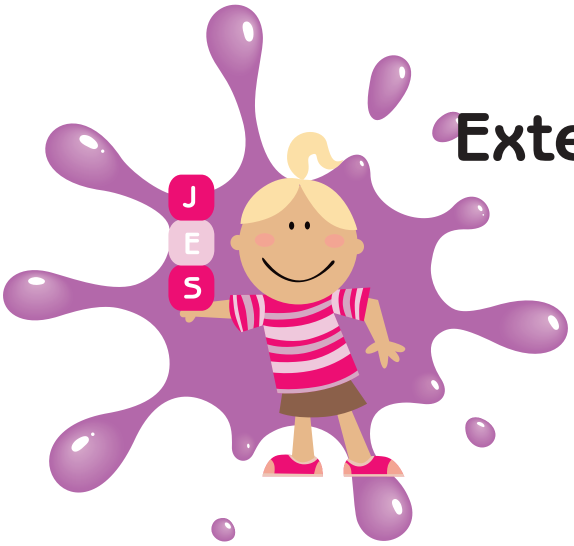


Extended Abstracts II: European Science Education Research Association (ESERA) Conference 2013 Introduction

■ Michael Allen

I was fortunate to attend the recent and prestigious European Science Education Research Association (ESERA) Conference, which was held at the attractive venue of the University of Cyprus in Nicosia from 3rd – 7th September 2013. Presenters came from all corners of Europe, from Scandinavia to Turkey. In addition to a diverse European presence, North America and even Japan were represented making the Conference truly international. There was much on offer here for the science educator, with an incredible 226 sessions running over the five days (there were between 4-8 papers per session). Four sessions were dedicated to science in the early years, constituting a total of 20 papers or posters.

When the Editors of *JES* asked me to write a review of selected abstracts from the ESERA Conference, it was at first difficult to decide which to choose – each of the 20 early years presentations had value in its own way and made a contribution towards advancing the field of emerging science. I wanted a common theme across the articles to be *improving children's conceptual development by means of effective classroom experiences*, which is a personal interest. I also looked for research that had clear and pragmatic implications for the early years practitioner, and each of the four abstracts has very specific recommendations in this regard. This attribute makes the research findings more immediately usable for practitioners and contrasts with studies that have broader implications, which are more vague and generic.

The four pieces are extended abstracts; that is to say they give a précis of the study, which includes details of background, methodology, etc. that are usually omitted from a normal abstract due to lack of space. They give the reader an 'executive summary' that reports all necessary detail without the need to read the full article. The four abstracts originate from different parts of the world and so one might think that they would convey variations of early years science that are culturally diverse. In fact, there are more similarities than differences, reflecting standardised approaches adopted by researchers who are geographically divided. I believe this commonality and consensus to be encouraging.

Anna Windt and colleagues describe a German study, which compared different approaches to teaching experiments in a pre-school setting where the degree of pupil autonomy was altered as part of the research design. It is sometimes assumed that children learn best during science lessons when they have the freedom to carry out investigations independently without too-close supervision, but this assumption is clearly challenged by data from this study. There has been a strong French tradition of excellent research exploring how children learn physics: for example, Edith Guesne's work on light misconceptions during the 1980s. Delserieys Pedregosa *et al* continue this work with a study into the effectiveness of a pedagogy designed to encourage the construction of scientifically acceptable concepts of shadow phenomena. Yamahashi *et al* examine which types of science reading books young Japanese children prefer and suggest several attributes of these books that may encourage children to read more about science. Completing the quartet, Allen summarises research that investigated English pre-school children's ideas about which species they believe to be animals, fish, birds, etc., with some surprising results.

Extended Abstracts II (i)

Scientific experiments in early childhood education: Different learning opportunities and implications in practice

■ Anna Windt ■ Rupert Scheuer ■ Insa Melle

Abstract

Integrating natural sciences in pre-school education has become popular over recent years. Conducting small experiments is a key method in this context. One reason for this trend can be gleaned from findings concerning the development of pre-school students; pre-school students are not scientifically illiterate but have the cognitive requirements to understand scientific phenomena. They have some science knowledge in specific domains upon which they can build new knowledge. Additionally, there are hints that pre-school students are capable of gaining knowledge through scientific experiments. However, there is a lack of information about how learning opportunities must be structured in order to be most efficient for pre-school students. The goal of the present study was to gain knowledge about the impact of scientific experiments on the competences of pre-school students. Three different learning opportunities were compared, which differed in the degree of autonomy of the children as well as the role of the nursery staff. They all had in common that, over a period of two weeks, groups of four to seven pre-school students conducted the same experiments based on identical worksheets for about 45 minutes. The study shows that pre-school students are generally capable of gaining competencies through scientific experiments and gives hints that pre-school students therefore might need instructions from a nursery school teacher, though the structure does not have to continually be present. The main study involved twelve nursery schools, with 221 pre-school students.

Theoretical background and problems

Integrating natural sciences in pre-school education has become popular over recent years. One reason for this trend can be gleaned from findings concerning the development of pre-school students; Koerber, Sodian, Thoermer and Nett (2005) found that pre-school students are not scientifically illiterate, but have the cognitive requirements to understand scientific phenomena. They have some science knowledge in specific domains upon which they can build new knowledge (Gelman & Brenneman, 2004). Additionally, there are hints that pre-school students are capable of gaining knowledge through scientific experiments (e.g. Lück, 2006).

However, there is a lack of information about how learning opportunities must be structured in order to be most efficient for pre-school students. Almost all approaches agree that conducting small experiments is a key method. Differences lie in the role of the nursery school teacher and the degree of autonomy offered to the children. How much guidance do pre-school students need? Should teachers present scientific phenomena to pre-school students and then talk to them about the explanations? Or should they just integrate materials into the nursery school that invite the children to explore phenomena on their own? Studies in primary schools show that students' learning outcomes benefit significantly from a clear, structured lesson (Hardy, Jonen, Möller & Stern, 2006). Likewise, Butts, Hofman and Anderson (1994) found out that primary school students develop less knowledge when they just gather experiences on their own, in comparison with those who receive instruction about the content in addition. Whether these findings can be extrapolated to pre-school education remains to be demonstrated.

Knowing that integrating natural sciences in pre-school education could promote many other competences in addition to knowledge about scientific phenomena, the current project focuses on competence knowledge (Windt, Scheuer & Melle, in press).

Hypotheses

The following hypotheses were investigated:

- H 1: Pre-school students are capable of gaining knowledge through scientific experiments.[1]
- H 2: The increase of knowledge depends on the learning opportunities.

Methods and design

Concept of the learning opportunities

Regarding the learning opportunities, the 'small group' and the 'researcher's corner' were compared. Both have in common that four to seven children conducted the same experiments based on identical worksheets for 45 minutes per day. In the small group, the children conducted the experiments under the instruction of a nursery school teacher who structured their proceedings. In the researcher's corner, the children conducted the experiments on their own and the nursery school teacher was located in the room as a reference person.

There are four ways to combine the two learning opportunities (Figure 1). The children can experiment in the small group exclusively (S) or in the researcher's corner exclusively (R). In addition, a combination of small group and researcher's corner was investigated (C), where small group and researcher's corner changed daily. This combination is interesting, because the students might learn strategies through experimenting with the teacher, which they could use while experimenting on their own. The baseline (B) did not conduct experiments at all but did the tests only to control the test-retest effect.

Arrangement of the groups

Twelve nursery schools with 221 pre-school students participated in the study (see Figure 2). All four groups were created in each nursery school and the same teacher was responsible for all of them. The teacher rated the children on an assessment sheet regarding the categories 'language skills', 'cognitive development', 'fine motor skills', 'social competence' and 'interest in natural sciences' and the groups were arranged based on this rating. The reliability of the sheet is good: .82<α<.95 for the five scales. In addition, a cognitive abilities test was conducted to check the comparability of the four groups.

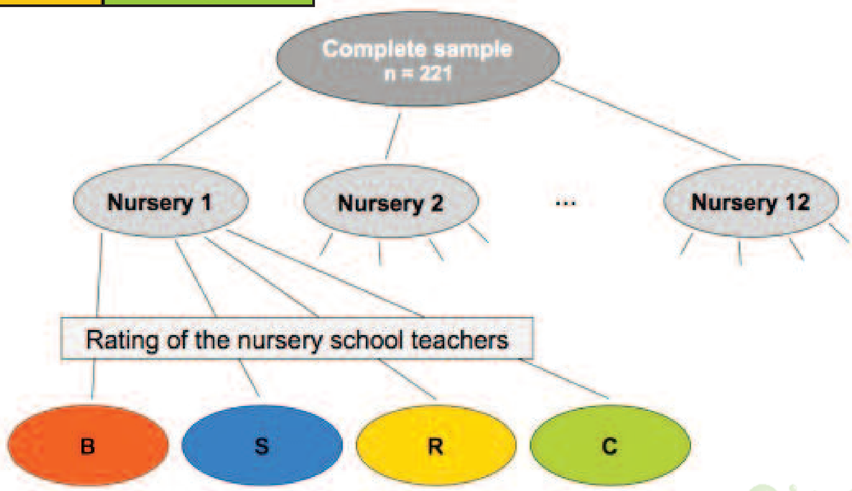
Course of the study

The study took the form of a pre-post-test design. After the pre-test, all three intervention groups received an induction into experimenting, which should have enabled them to experiment on their own. They learned how to use a pipette, worked out rules for experimenting, etc. They then conducted experiments for two weeks, every group in their own style, after which all four groups were tested again.

Figure 1: 2x2 matrix of the learning opportunities

		Small Group	
		no	yes
Researcher's Corner	no	Baseline **B**	Small Group **S**
	yes	Researcher's Corner **R**	Combination **C**

Figure 2: Arrangement of the four groups



[1] 'Pre-school students' refers to children in the last year of the nursery school when they are five or six years old.

Worksheets

To enable the children to conduct the experiments on their own, worksheets were developed. Since the literacy skills of the students were limited, the worksheets were colourfully illustrated to aid comprehension. All worksheets consisted of three pages. The first page showed all materials in their required quantity (Figure 3). On the second page, pictures illustrated step-by-step how the experiment has to be conducted (Figure 4). In that experiment, the children tested whether different substances dissolve in water. The third page had space to paint the observations.

Knowledge test

Figure 5 shows one of the twelve items in the knowledge test. All items contained one question, one attractor and three distractors.[2]

Groups of four to seven children were tested. Every child received a booklet with the items and a pencil and the researcher then read the questions and the possible answers aloud.

[2] α = .63, which is acceptable for such a short test for pre-school students and which suffices for the planned comparisons of groups.

Figure 4

Figure 3

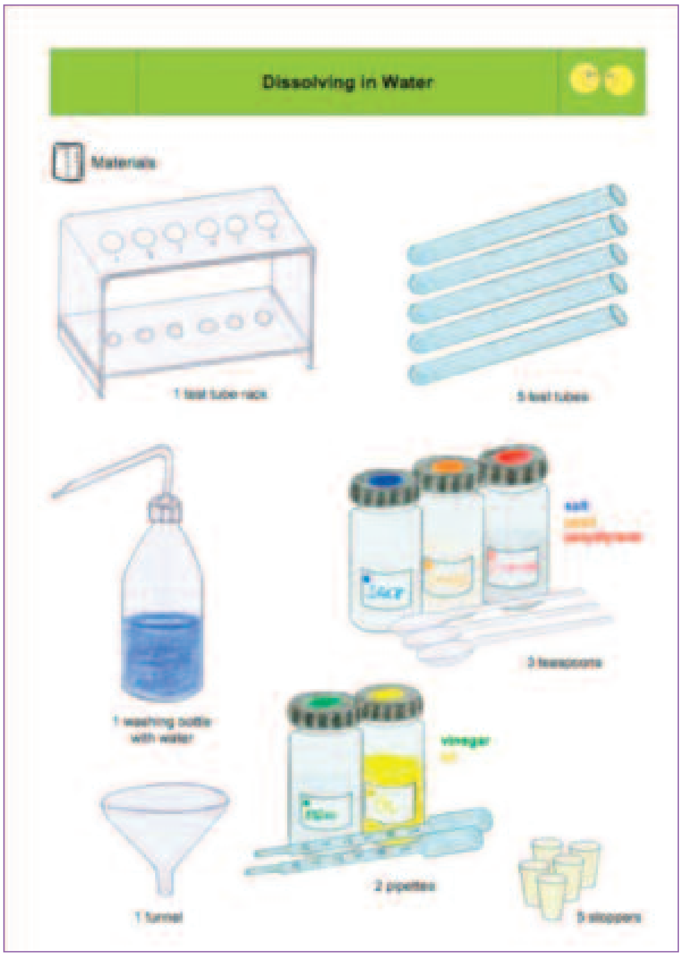
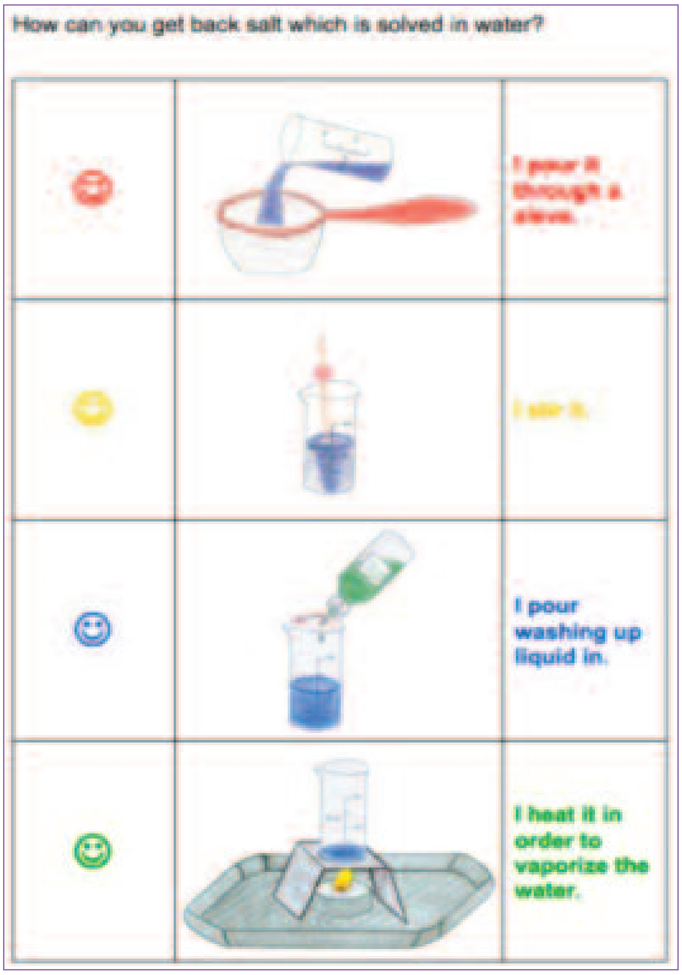


Figure 5



Results

The four groups, B, S, R and C, were comparable regarding the rating of the nursery school teachers, their prior knowledge and their cognitive abilities.

Comparison of pre- and post-test

Figure 6 shows the mean scores pre- and post-test of the baseline and the three intervention groups together. The difference between the increase of knowledge of two groups is highly significant and there is a strong effect: $p < .001$, $d = 0.73$. Therefore, Hypothesis 1 was confirmed.

Comparison of the learning opportunities

In Figure 7, the mean standard residuals pre- and post-test are shown. The increase of knowledge of the small group and the combination are almost equivalent and higher than the increase of knowledge in the researcher's corner, but the differences are not significant: $F(2,132) = 1.784$, $p = .172$, $\eta^2 = .026$. So, Hypothesis 2 could not be confirmed.

Conclusions

Hypothesis 1 was supported by the evidence. This confirms that it is not too early to teach natural sciences to pre-school students. Nevertheless, it is necessary to find out more about the capabilities and limits of pre-school students to facilitate an allocation of responsibilities between nursery and primary school.

In contrast, Hypothesis 2 could not be confirmed. There were differences between the learning outcomes, but they were not significant. This might be caused by the large dropout of about 20% demonstrated by children in the researcher's corner. Thus, only trends can be deduced from this study, which would have to be applied to a larger sample if more meaningful statistics were to be gained. It appears that pre-school students need some form of instruction from the nursery school teachers, because the groups S and C reached a higher increase of knowledge than group R. However, it also seems that this instruction does not have to be present daily, as the increase of knowledge in the groups S and C were almost equivalent. Nursery school teachers are not dispensable, but they do not have to guide pre-school students all the time, which fits in with the general approach in early childhood education.

Figure 6: Mean scores pre- and post-test

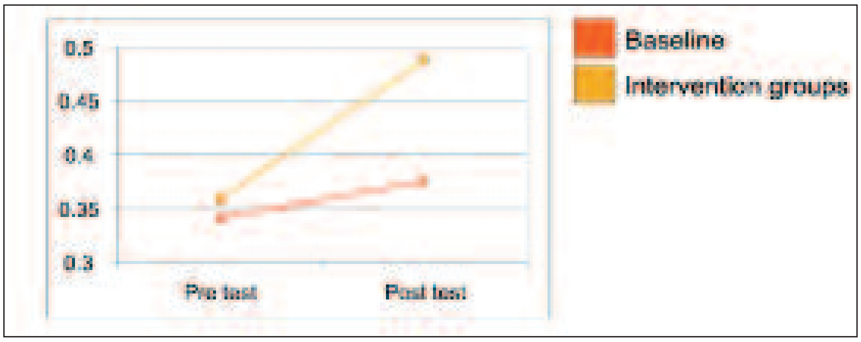
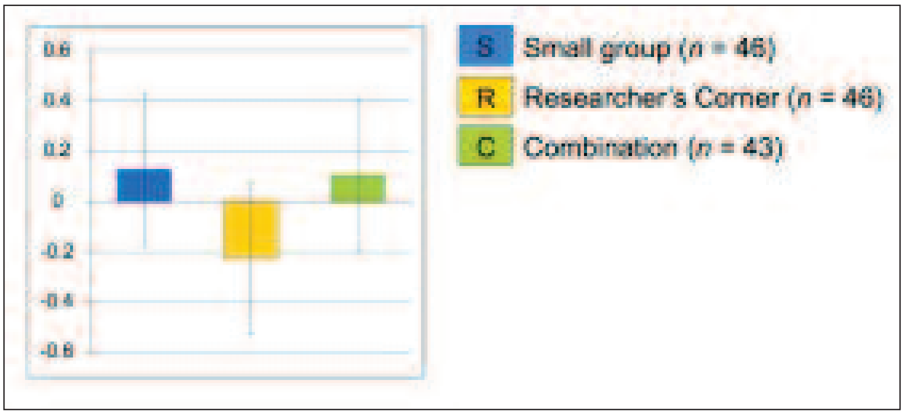


Figure 7: Mean standard residuals pre- and post-test



Further implications for emergent science practice

Beyond these conclusions there are some additional minor implications of the study that apply to emergent science practice: a duration of about 45 minutes is appropriate to conduct an experiment with five- to six-year olds. It is enough time to prepare, conduct and discuss an experiment and it is not too long for the concentration of the children. It is recommended that groups of seven children be the maximum, and then the nursery school teacher has enough capacity to support the children, to instruct them or to be a helpful reference person when problems or questions arise.

Colourfully illustrated worksheets in combination with an introduction into experimenting enabled even five- to six-year olds to experiment on their own. A video analysis of three children in the researcher's corner over the time of 10 experiments showed that the children used the time very efficiently for experimenting; 93% of the time was coded as a meaningful interaction period with the scientific phenomena.

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Extended Abstracts II (ii)

Pre-school children's understanding of a precursor model of shadow formation

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Abstract

The present work is part of a research study that addresses the question of conceptual understanding of science for young children (aged 5-6 years). The aim is to present situations that can enhance teaching efficiency in early science education, particularly to support the science teaching in pre-schools. We present results that test the effectiveness of a teaching intervention about the formation of shadows in two French pre-schools (33 children). The aim of the teaching intervention is to destabilise children's representations to help them construct a precursor model that explains the formation of shadows. Its efficiency has been previously proved in Greece with teachers who have a good awareness of research in science education. It was implemented with two experienced French teachers in their regular classroom organisation. The analysis of children's ideas shows that the teaching intervention has a positive effect, but differences remain in the progress of some children compared to others.

Background

There is general agreement that science education should start as early as possible for all children (Eshach & Fried, 2005). The idea is supported by many communities, both scientific and political. It is generally justified by the natural curiosity of very young children who tend to favour scientific activities (Léna, 2009) and the influence this has on an early start in their future school career (Eurydice, 2009). However, there is a large variety of early education settings for young children before compulsory schooling. In France, the choice was made to define a structure for nursery school that resembled the model of elementary school. Teachers are qualified to teach at any level of primary school (children from 3 to 10 years), with no specific specialisation for nursery education or science education. This results in a national curriculum focusing on language development and social skills to help children become 'schoolchildren'. More generally, despite the interest in early science education in many countries, early education curricula rarely give any significant place to scientific concepts or reasoning (Eurydice, 2009). We therefore note a strong contradiction between what is said about science education and what is offered to young children.

The present work is part of a wider research study interested in the question of conceptual understanding of pre-school children in science education. The aim is to present strategies that can enhance teaching efficiency in early science education to provide an education for all children (e.g. give children opportunities to make their own ideas explicit, provide alternative solutions, explore ideas through open-ended questions), supporting the implementation of effective science education in pre-schools. In this paper, we investigate the efficacy of a teaching intervention about the formation of shadows in two French pre-schools. We base our analysis on children's ideas as defined by Givry and Roth (2006). According to these authors, the meaning expressed by the children can be reconstructed by the researchers through semiotic resources contained in language. In other words, children's ideas are defined using analyses of their talk, gestures and use of salient elements of the situation.

The teaching intervention used in this work is derived from a series of previous researches. It is based on a socio-cognitive approach, which combines results from social and cognitive psychology with results from research in science education (Ravanis & Bagakis, 1998; Ravanis, 2010). In particular, it is based on the idea that the learning process should take into account the knowledge previously acquired by children to help them develop scientific thought about the phenomenon. In that sense, some researchers explore the construction of the physical world in young children's thoughts using the concept of the precursor model as an intermediate entity between children's first representation and the associated scientific model (Ravanis, 2010). Furthermore, previous researches highlight the interest of organised teaching strategies that focus on critical obstacles with the aim of overcoming these obstacles (Martinand, 1986; Ravanis, 2010). Finally, in this teaching intervention, learning is understood as a product of social interactions focusing on targeted concepts with the teacher playing a role of mediation and tutoring (Dumas Carré & Weil-Barais, 1998).

Considering the theoretical background defining the teaching intervention, we made the hypothesis that it would have a positive effect on children's understanding of the precursor model of shadow formation in a 'regular classroom environment'.

Shadows are a natural phenomenon, allowing children to build their own representations through everyday experience (Chen, 2009). According to Ravanis (1996), these representations can reflect a difficulty in identifying non-transparent objects as obstacles to a light beam. Following this idea, three main obstacles were identified *(Ibid):* 1) explaining the phenomenon of shadow formation; 2) defining the position of the shadow according to the position of the light source and the object; and 3) making the correspondence between the number of light sources and the number of shadows.

Methodology

The objective of this research is to identify if French 5-6 year-old children are able to reach a better understanding of shadow formation following a teaching intervention carried out in Greece (Ravanis *et al*, 2005). The aim of the intervention is to destabilise children's representations to help them construct a precursor model that explains the formation of shadows. The main feature of this model is the definition of this phenomenon as the result of the propagation of light being blocked by an object. The efficiency of the teaching intervention has been previously demonstrated in Greece in a context of close collaboration between teachers and researchers and small group of children (2-3) during the intervention itself *(Ibid).* The teaching intervention was implemented in France in a 'regular classroom environment', which we define as a context close to the standard organisation of a French pre-school class. As a result, it is assumed that the teachers involved did not have to change many of their habits in terms of class management during the teaching intervention. Two

Table 1: Description of the teaching intervention: steps of the teaching intervention on shadow formation.

	Teacher's task
STEP 1 To make children's own ideas explicit to destabilise representations	Provides a lamp and places a vertical object on the table. Asks each child to form a shadow with the lamp and to give an explanation. Focuses children's attention on where the object is lit by the lamp and asks the children if the light can go through the object.
STEP 2 Construction of a precursor model 1	Asks children to predict the position of the lamp and the object to form a shadow at designated places. Children then form the shadow. Brings the children to an agreement on the fact that the shadow is from the other side than the lamp with respect to the object. Impossible task: Asks the children to form a shadow on the same side of the lamp with respect to the object; engages in a discussion on why the task is impossible.
STEP 3 Construction of a precursor model 2	Provides several lamps to the group (at least one per child). Asks the children to form more than one shadow. Asks the children to predict the number of shadows with 2 lamps. Guides children in successively turning on and off the different lamps while predicting the results of these operations. The aim is to help children make the correspondence between the number of shadows and the number of lamps.
Equipment	5 to 6 lamps A simple vertical object (such as a wide stick)
Duration ***Classroom organisation***	20 minutes Groups of 5 to 6 children sitting around a table

teachers were informed about the teaching intervention and its theoretical underpinning by means of a written document. The different steps of the teaching intervention are provided in Table 1. They implemented the teaching intervention with groups of 5-6 children. The research protocol included pre- and post-interviews within two weeks of the teaching intervention *(Ibid).* The interviews were individually conducted by researchers and consisted of three tasks aimed at collecting children's ideas (the results of which are summarised in Table 2):

- Task 1: Using sunlight, the researcher invited the child to observe the shadow of an object in the classroom, then asked him/her to describe and explain how shadows are formed.
- Task 2: The researcher placed a lamp and an object in front of the child. He asked him/her to predict where there would be shadow if the lamp was lit, and explain this prediction.
- Task 3: The researcher placed two lamps and an object in front of the child. He asked him/her to predict where there would be shadow if the two lamps were lit simultaneously, and explain this prediction.

Thirty-three children aged 5-6 years were involved from two different schools. All three phases of the protocol were videotaped to collect data on children's talk, gestures and use of salient elements. For this study, only data from the interviews were analysed. In Task 2, for example, a child's idea was reconstructed from what they said *('because you place the lamp on that side, there is the shadow on that side')*, from gestures (pointing out successively the lamp and an area on the table), and salient elements (the lamp and the area on the table with respect to the object 'side'). Children's ideas were categorised into three groups (sufficient, intermediate, insufficient), using the precursor model defined previously, and were analysed statistically.

Results

Overall, the data analysis showed that French children progressed in building a precursor model. In fact, 22 of 33 succeeded in at least one of the three tasks. A test of independence, carried out for each task, demonstrates the effectiveness of the teaching intervention (Khi2 obs >> Khi2 th). To go further, we consider that the results from the Greek study can be used as a benchmark to assess the efficiency of the teaching intervention. Table 2 shows the frequency of responses of the two populations (French and Greek). A homogeneity test shows that, during the pre-test, the two populations are identical (Khi2 obs << Khi2 th). After the teaching intervention, the analysis of children's responses to post-test shows more nuanced results. For Tasks 1 and 3, the homogeneity test shows a difference between the frequency of Greek and French children's responses (Khi2 obs >> Khi2 th). For Task 2, the trend is reversed and the populations are getting closer (Khi2 obs < Khi2 th).

In summary, the teaching intervention, implemented by experienced teachers in a 'regular classroom environment', has a positive effect on French children's attainment of the precursor model of shadow formation. However, the progress of French children is more pronounced for Task 2 than Tasks 1 and 3.

Implications for professional development

The implementation of a teaching intervention is a dynamic process that involves teachers interpreting and, as a result, modifying the intervention. As a result, it is necessary to analyse the activity of the teacher and each individual child in the teaching sequence to better understand the significant progress of some children only and the better results for Task 2 in the pre- and post-tests. Three hypotheses were highlighted in this article, in accordance with the theoretical underpinnings and first video analysis of the teaching

Table 2: Frequency of answers of French and Greek children

		Pre-test France	Greece	Post-test France	Greece
Task 1	Sufficient	2	3	7	27
	Intermediate	20	19	23	1
	Insufficient	11	13	3	7
Task 2	Sufficient	2	1	15	26
	Intermediate	2	7	2	0
	Insufficient	29	25	16	9
Task 3	Sufficient	1	4	12	32
	Intermediate	4	6	0	0
	Insufficient	28	25	21	3

interventions. First, the child's relationship to the critical obstacle in the formation of shadows is influenced by their having to solve an impossible task (forming a shadow in the same side as the light source with respect to the object). Secondly, the child's relationship with the equipment provided and the experimental set-up influence the way of comprehending the concept. Finally, the child's relationship with language and interactions with others are seen as major factors in the study.

From the perspective of teachers' professional development, we can say that this work proposes a teaching intervention that can be implemented directly by pre-school teachers. It shows that it is possible to introduce science concepts in early education with short and simple tasks. Moreover, such an activity does not require extensive materials, time or complex class management. However, the study highlights the limits of providing teaching resources with no further training. In particular, one of the implications of the study seems to indicate that teachers who are aware of the findings of research results, such as the group of Greek teachers involved in the first study, are more effective when helping children to construct a precursor model on shadow formation.

In the case of the teaching intervention on shadow formation that we propose, we believe that there are two key elements. First, it is important for teachers to understand that the main objective is to help children to identify non-transparent objects as obstacles to a light beam. In that sense, the impossible task is seen as a way to focus pupils' attention on the object and the result of its interaction with light. Subsequently, the introduction of more than one light source encourages children to identify a shadow and its corresponding light source, still with respect to the object. Many teaching resources on shadows for very young children tend to involve children's own shadows with a focus on the shadow and its size, with respect to the light source. When an object is involved, the focus tends to be put on the shape of the shadow depending on the nature of the object. Rather than focusing on shadow properties, the teaching intervention proposed here insists on the relations between three elements: light source, opaque object, shadow. Secondly, the system of interaction between knowledge, the teacher, the learner and the artefact may induce a change in teachers' practices that include a mediating role for the teacher (Lenoir, 2011). This involves a dimension where interactions of teacher-learner and learner-learner play a major role when teacher and learners share the same intention: to get involved in learning processes (Dumas Carré & Weil-Barais, 1998). Such a mediating system requires teachers to *'go from a vision of transmitting knowledge to one of being a mediator'* (Lenoir, 2011, p.113).

More generally, this study questions the place of research in teacher education and professional development and the role of research communities in sharing research results and working together with teacher communities (Johnson, 2006). The present study is based on a collaborative work between researchers and teachers to develop teaching materials (Ravanis *et al,* 2005). The positive outcomes of such collaborations have been highlighted by other studies (Coppe & Tiberghien, 2010) that show, for example, the interest of *'research experiences for teachers'* (Blanchard, Southerland & Granger, 2009).

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Extended Abstracts II (iii)

Characteristics of science picture books liked by Japanese children

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Abstract

Science picture books are one means of enriching science education during early childhood. However, no previous study has focused on the characteristics of science picture books from children's perspectives. This study attempts to identify the characteristics of the content, pictures and words described in science picture books liked by Japanese children aged six to seven years, using the series *Kagaku no Tomo* ('My Body Science Series'), which has been evaluated highly by Japanese educators. A total of 50 books were used and subjects included physics, chemistry, biology, geoscience, mathematics and technology. One teacher read one book a day to 39 children during 'homeroom' at their primary school. Children were asked to rate the content, words and pictures in the book read that day on a four-point Likert-type scale. After all 50 books were read, the books with the highest scores were identified. On this basis, a questionnaire survey and interpretive analysis were conducted. During the former, questionnaires were intended to help children freely describe the reasons behind the high-scoring book in each area. In the latter, the characteristics of the relevant aspect of the books were analysed using interpretive research methods. Through the results of the questionnaire survey and interpretive analysis, it may be said that the science picture books liked by Japanese children in early childhood have the following characteristics. The content liked by the children focuses on the dynamism of life and introduces the time course from birth to death. With regard to the pictures, the depictions of characters and animals are vivid and easy to understand, and help the children learn what things look like in the real world. Finally, the words liked by the children were chosen because they are those that children in early childhood can understand and were placed in a 'symmetric and overlapping relationship' with the pictures.

Purpose of the study

In recent years, studies have been conducted on early childhood science education across the world (e.g. Roth, Goulart & Plakitsi, 2013; Tunnicliffe & Johnston, 2011). Science picture books are one means to enrich science education during early childhood (Monhardt & Monhardt, 2006; Pringle & Lamme, 2005). However, no previous study has focused on the characteristics of science picture books from children's perspectives to, for example, verify what characteristics make children like or dislike particular science picture books. Identifying the characteristics of appealing science picture books from a children's perspective will provide valuable insight for the development and implementation of early childhood science education using science picture books.

Research method and design

Research question

What characteristics are found in the content, pictures and words in science picture books that are liked by Japanese children in early childhood?

Participants

The survey was conducted amongst 39 Japanese children aged six to seven years.

Context

A total of 50 science picture books were used in this study from the series *Kagaku no Tomo.* Included in the series are science picture books on physics, chemistry, biology, geoscience, mathematics, technology, etc., with each volume comprising approximately 20 pages. During the study, a teacher read one book a day to 39 children during 'homeroom' at their primary school. A projector screen was set up at the front of the classroom, and the science picture books were projected with a document camera so that all the children could easily see the pictures and words while the teacher read aloud.

Data sources and analysis

Children were asked to rate specific elements – content, words and pictures – of the book read that day on a four-point Likert-type scale after the reading was finished. After all 50 books were read, the scores for each element were calculated and the books with the highest scores identified. For content, the book with the highest score was *Toki* ('The Japanese Crested Ibis'); for pictures, it was *Itachi* ('The Weasel') and, for words, *Michi* ('Roads'). On this basis, a questionnaire survey and interpretive analysis were conducted. In the former, the questionnaire was intended to help children freely describe the reasons behind the high-scoring picture books mentioned above. The questionnaire was administered to all the children in the class together, and answering it required approximately 30 minutes. Questionnaire answers were sorted into categories. In the analysis, the characteristics of the relevant aspect of the top-scoring book in each area were analysed using interpretive research methods.

Results

The questionnaire survey

- **Content**

The children mentioned that they liked features such as 'growth of living creatures', 'living creatures and seasons', and 'predation of living creatures', and that these were reasons for the high score. For example, answers were given such as *'I could see how babies of Japanese crested ibises were born'.*

- **Pictures**

Children mentioned 'graphic depictions of weasels' as one of the reasons for the high score; more specifically, answers such as *'I could feel the speed of weasels'* and *'I liked the pictures because they were vividly drawn in pencil'* were noted. Also mentioned was the fact that not only weasels themselves, but also the 'habitats of weasels' were shown. In addition, *'I could see the content of the story by looking at the pictures'* was noted as a reason.

- **Words**

The fact that *'the story can be understood intuitively'* was given as one reason; for example, answers such as *'It is easy to understand because names were included in the sentences'* were given. In addition, *'the words match the pictures'* was given as a reason; for example, answers such as *'It was good that the pictures matched the words'* were given.

An interpretive analysis

- **Content**

The analysis shows that the content of *Toki* has at least three characteristics making it more appealing to children. The first is the process from birth to death of living creatures. From the time when a Japanese crested ibis lays its eggs, to the hatching of young birds, and on to their deaths, the lifecycle of a Japanese crested ibis is described. The second characteristic is the lifestyle of living creatures in the four seasons; how Japanese crested ibises live during each of the four seasons is described. The third characteristic is the conservation of living creatures; the book introduces the fact that the population of Japanese crested ibises is decreasing and mentions that the people of Sado Island are trying to conserve them.

- **Pictures**

The analysis shows that the pictures used in *Itachi* have at least two appealing characteristics. The first is the fact that the images accurately depict living creatures and natural scenery. The second characteristic is creative composition and change of scene. For example, in the scene where a baby weasel is being attacked by an owl, the owl is positioned on the right and the weasel on the left, as if to go against the direction of the book. Here, the baby weasel is attacked and captured by the owl.

- **Words**

The analysis shows that the words used in *Michi* have at least two appealing characteristics. The first is the use of short words that can be understood intuitively. For example, one of the double-page spreads has only the phrase 'narrow road' written on it, while another double-page spread displays the phrase 'Single road, fork in the road. Let's go to the right'. The second characteristic is that the words match the images. For example, the phrase 'road for trains' is written beside the image of a railway track.

Discussion and future work

The findings of this research are based on a case study conducted with a small number of children using a particular series of science picture books. With this *caveat* in mind, it may be said that the science picture books liked by Japanese children in early childhood have the following characteristics. The description of life seems to be the main characteristic of the content liked by the children. The content of *Toki* focuses on the dynamism of life and introduces the time course from birth to death, the predator–prey relationship of animals and the principle of respect for life. With regard to the pictures, vividness and accuracy are the main characteristics liked by the children. The depictions of characters and animals are vivid and easy to understand, and help the children learn what things look like in the real world. Finally, the words liked by the children were easy to understand and well matched with the pictures. In other words, words were chosen that children in early childhood can understand and were placed in a *'symmetric and overlapping relationship'* with the pictures (Nikolajeva & Scott, 2006), in that the words and pictures both describe the same things.

We can provide recommendations for early years practitioners based on the findings of this study. First, in order to immediately increase children's curiosity and interest in science, we suggest that practitioners should select the science picture books with characteristics liked by children. Children may be familiar with the science picture books with these characteristics. Such science picture books can support children in entering the world of science. Secondly, if using science picture books *without* characteristics liked by children, we suggest that the practitioners prepare extra support during the storytelling session, such as providing concise commentaries on the content or pictures of science picture books, and compensating for the lack of the words. Some science picture books are not pedagogically and scientifically valuable because children do not like their characteristics. By adding pedagogical support, practitioners are able to communicate the value of the science picture books without characteristics liked by children. In the future, the validity of these characteristics should be verified by checking whether they are seen in other science picture books that received high scores, but not in those books that received low scores, using similar methods to those adopted here.

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Extended Abstracts II (iv)

Taxonomic knowledge of very young children relating to animal species

■ Michael Allen

Abstract

Previous research has established that learners can misclassify animals by failing to follow the tenets of accepted taxonomic rubrics. Compounding the problem, they unwittingly apply these misconceptions to areas of biology where secure knowledge about living organisms is a prerequisite, such as evolution, genetics, photosynthesis, and ecosystems. The current study represents an attempt to explore the classification knowledge of children aged 3-5 years, in order to compare both their performance and qualitative reasons for their classification decisions with those previously determined in older learners. As well, patterns in the way that taxonomic knowledge progresses between the ages of 3-5 years were sought in order to illuminate any potential origins of misconceptions. A quantitative and qualitative mixed-methods methodology was employed with a sample of 75 children, utilising a structured interview method to determine their ideas about the taxonomic labels *animal*, *fish*, *amphibian*, *reptile*, *bird*, *mammal* and *insect*. Findings reveal that children in all three age groups had many of the same misconceptions that have been determined previously in older learners. The five year-olds were generally better than their younger counterparts at classifying archetypal species; for instance, the clownfish into their fish taxon. However, conversely, the three year-olds were generally better when they classified non-archetypal species; for instance, the crab, which represents a decline in learning with age. Reasons for these declines are discussed using contemporary theories of child development along with their implications for early years educators.

Background

It is well established that children can hold misconceptions about which organisms they categorise as being 'an animal' (e.g. Bell, 1981; Braund, 1991; Chen & Ku, 1998; Patrick & Tunnicliffe, 2011; Prokop *et al*, 2008; Trowbridge & Mintzes, 1988; Tema, 1989; Tunnicliffe & Reiss, 1999; Tunnicliffe *et al*, 2008). Commonly, these misconceptions manifest themselves as under-generalisation of the 'animal' concept. For instance, children typically cite large, terrestrial, quadrupedal mammals as falling into this category, while others such as birds, fish, insects, crustaceans, etc. are seen as not being animals. Instead, children can create their own categories, each lying outside of the 'animal' set, not subsumed within the overarching 'animal' hierarchical level. Similarly, there are misclassifications related to lower taxonomic levels; e.g. a penguin is an amphibian because it lives on both land and water, a bat is a kind of bird, and a jellyfish is a type of fish.

Contribution of the research

Although previous workers have studied these misconceptions both quantitatively and qualitatively in older children and adults, there is little previous work that has accrued a sample of pre-school children. In fact, this age group has been neglected generally in the field of substantive scientific conceptual research. In addition, the current research represents the first study to examine *all* the target concepts using a statistical approach where any inferences are required to be borne out by statistically significant relationships. As such, it is intended that the study will carry a good degree of robustness that will be acceptable to external scrutiny, and add to the findings of others.

Purpose

The objective of the research was to undertake an exploratory study of the concept *animal* and related entities, using a sample of children aged 3-5 years. Research questions were:

- How do children aged 3-5 years conceptualise *animal* and the related taxonomic entities of *fish*, *amphibian*, *reptile*, *bird*, *mammal* and *insect*?
- Are there qualitative differences between these entities and those conceptualised by older participants, as reported in the literature?
- Are there any identifiable patterns in the way that children's ideas about taxonomy progress from ages 3-5 years?

Participants and setting

The research was carried out using 75 participants aged 3-5 years accrued from eight different institutions in the south east of England, either primary schools, nurseries or playgroups. Twenty-five children from each of the three year groups took part.

Design and methods

Each child was interviewed by two researchers using a structured schedule. Plastic models of each case were used as cues to help children express their scientific ideas without the need to read text or write responses. The aim of the interview was to ascertain each child's understanding of the taxonomic labels *animal*, *fish*, *amphibian*, *reptile*, *bird*, *mammal* and *insect*, which was achieved by having the child carry out seven simple sorting tasks, one for each taxonomic label. For each task, the researchers presented the plastic models and the child decided whether or not the taxonomic word in question was an appropriate label for each model by placing it in either a 'yes' or 'no' set.

Analysis of data

Data were analysed using quantitative and qualitative methods in order to determine both the frequencies of and reasons why children categorised each case. Data are presented in three elements: *frequency data*, *correct choices* and *qualitative reasons.* Statistical operations that were undertaken were simple and complex Chi-square for goodness of fit (see Appendix 1).

Research outcomes

Overall, the sample as a whole performed well with the animals, birds and fish taxa, making many taxonomically correct choices. They performed less well with the insects and reptiles taxa, and poorly with the amphibians and mammals. Previous workers have determined that learners of all ages can misclassify animals and that performance improves with age. The current study provides data to show that 3-5 year-olds can also be susceptible to these same misconceptions, and that some of them similarly dissipate with age. However, with most of the taxa, there were also frequent *declines in performance* in one or more aspects of classification as age increased. Older children were more adept at classifying case species; for instance, they knew that a seahorse is a fish, but also at the same time started to include more non-archetypal species such as the crab into the taxon and so made more errors. Declines in performance by the older children were nearly always related to them considering taxonomically inappropriate criteria, usually habitat and means of locomotion. The younger participants tended to focus solely on anatomical criteria and as such made fewer misclassifications.

The three year-olds particularly did not use the more abstract criteria, which perversely helped them perform better in many of the classification tasks. This is thought likely due to two factors working singly or in combination. First, the younger children had less life experience and knew fewer facts about animals, which meant they had less knowledge to draw upon concerning where an animal lived, how it behaved, etc. In one of the schools we visited, the 4 and 5 year-olds were provided with immensely rich experiences to support their learning in biology, which included a living pond, 'pet' invertebrates such as caterpillars in the classroom, a well stocked library, and so on. It is counter-intuitive to think that enhancing a child's general understanding of the world in this way may cause a regression in science knowledge, but this could well have been the case.

Secondly, there is a large body of literature in developmental psychology going back 50 years that has secured the understanding that, when young children are set classification tasks, they rely on superficial perceptual attributes and group cases together simply because they look alike (e.g. Flavell, 1963) – the crab and jellyfish simply did not look like the clownfish and so were not placed in the same set. For developmental reasons, they are thought innately incapable of observing beyond the perceptual level and so find it very difficult to spontaneously consider criteria such as habitat or locomotion. Thus, the cognitive causes of misclassifications are currently elusive, though probably complex and multivariate, but nevertheless there are clear implications for early years pedagogy.

Implications for practitioners

At a basic level, the current research informs interested early years teachers and carers of children's taxonomic concepts, including specific misclassifications, to which they may be susceptible between the ages of 3-5 years. This is particularly important when children first experience formal teaching of simple taxonomy at school, as baseline knowledge of what learners believe to be an animal, a fish, etc. will be of concern to practitioners prior to teaching the topic. This has immediate relevance in England since, from 2014, primary teachers in state schools will be obliged for the first time in the history of the National Curriculum to teach animal classification to children aged 5-6 years (DfE, 2013). Taxa will include *animal, fish, amphibian, reptile, bird, mammal* and *invertebrate*, with children being required to learn the names of the taxa, identify examples and describe and compare animals' structures. There is evidence to suggest that some elementary teachers have their own latent misconceptions about animal classification (Burgoon & Duran, 2012; Chen, Huang & Wang, 1994; Trowbridge & Mintzes, 1988); therefore, if biological taxonomy is to be taught effectively, early years practitioners both in England and elsewhere would ideally undergo some form of training or self-study to confirm their own knowledge.

In understanding how to classify biological species in a scientifically appropriate way, learners must first construct a mental prototype that reflects a typical instance of each taxon. This prototype can be compared with novel cases and the relevant choice is made whether to accept or reject that case from the set. Experience is crucial to the development of mental faculties, and so exposure to a wider variety of set exemplars (both archetypal and non-archetypal) will strengthen the prototype and sharpen the boundaries of the set, helping to differentiate it more clearly from other, competing sets (Posner & Keele, 1968). More recently, Oakes, Coppage and Dingel (1997) found that 10 month-old infants could categorise plastic models of animals more effectively when they were exposed to both archetypal cases as well as non-archetypal cases that were exclusive of the set, suggesting that the ability to enhance a prototype using varied exemplars is fundamental to categorisation. Young children are capable of learning by rote (simple song lyrics, nursery rhymes, numbers, etc.), therefore teachers can provide a variety of cases that, with practice, children would be able to recall, helping them to overcome a seemingly-programmed tendency to classify using only physical features. When called upon, most pre-school children would be capable of recalling by rote a few exemplars of biological taxa, which seems to be one of the statutory tasks within the new English Science National Curriculum for Year 1 (ages 5-6 years). However, the application of many exemplars to further define the set would be more problematic – the danger here being that the unintentional assimilation of incorrect exemplars will only culminate in the construction of spurious sets.

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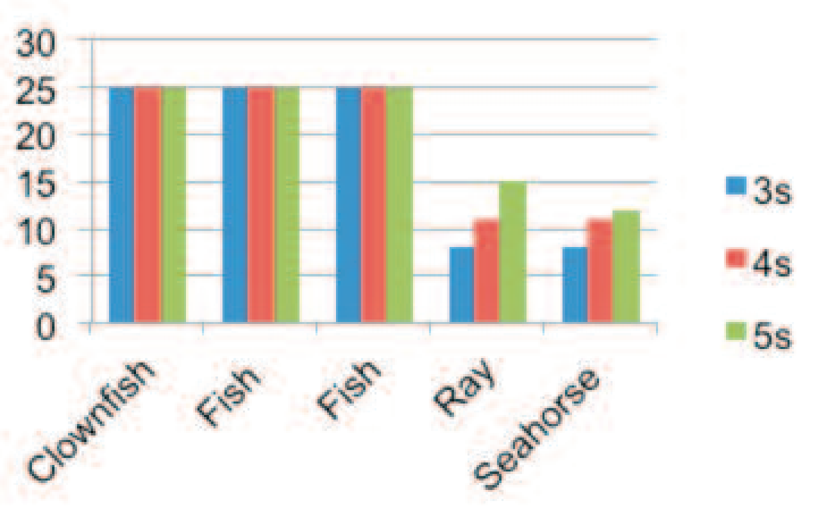
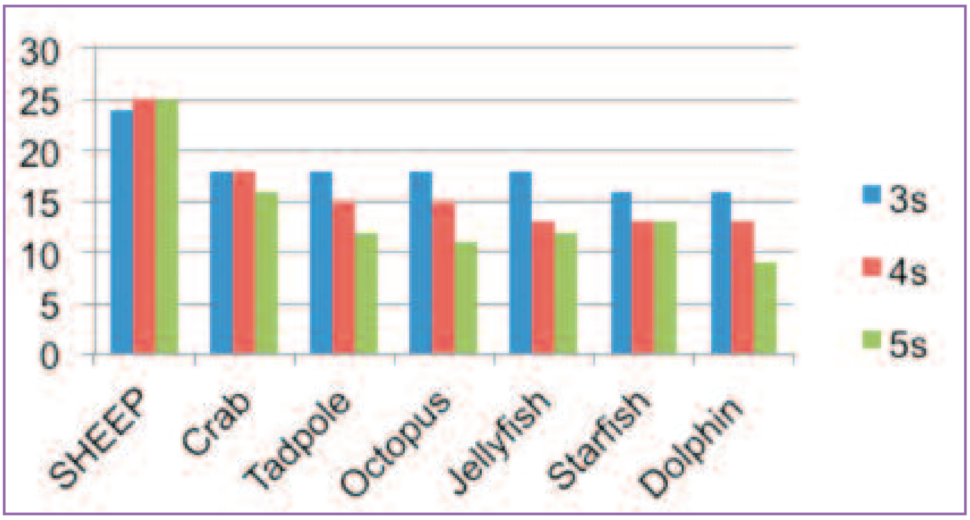
Appendix 1: Sample results (fish taxon)

Correct choices for fish (fish species) (n=25 per year group)



Correct choices for fish (non-fish species) (n=25 per year group)



Mean frequency ranking for fish (n=25 per year group)

	3s	4s	5s
Clownfish	25	25	25
Fish	25	25	25
Fish	25	25	25
Dolphin	9	12	16
Ray	8	11	15
Starfish	9	12	12
Jellyfish	7	12	13
Octopus	7	10	14
Seahorse	8	11	12
Tadpole	7	9	13
Crab	7	7	9
Sheep	1	0	0
Chair	0	0	0

Qualitative categories for fish (n=25 per year group)

	5s	4s	3s
Habitat	21	15	12
Locomotion	18	15	7
Appendages	20	11	6
Cites identity	4	9	15
Tail	12	10	6
Miscellaneous	10	9	6
Physiological	2	2	1
Body covering	2	0	1
Anthropocentric	0	0	1

Resource Reviews

Emergent Science
Teaching Science from birth to 8

By Jane Johnston. Published in 2013 by Routledge, London, price £24.99. ISBN 978 1 40 823764 9

In the introduction to this book, the author warns the reader that *'it is not designed to be "dipped into"'*, but rather relevant sections *'should be read and re-read…to support deep understanding'.* This is certainly a book that has much to offer the reader who is prepared to invest time and effort in engaging with the text and to use it as a tool to develop their understanding of emergent science and the issues surrounding it. This text not only has the potential to help develop the reader to be a more effective early years practitioner, but also to be a better informed and articulate member of the profession; there are certainly times when I wish that I had been better able to respond more swiftly and confidently to a parent who is worried that their child is 'only playing', or a colleague who fears that I am not challenging my early years children!

The book is designed to be used by professionals at varying stages of their career, with reflective tasks designed to stimulate the 'early career professional', the 'developing professional/teacher' and the 'later career professional/leader', although I found that all the questions had potential to prompt me to think about different aspects of my current role. There is also much information to support anyone interested in carrying out a research project in the early years. There are many examples of actual early years research carried out in recent years, which serve both to inform readers about current understanding of emergent science and effective teaching of this age group, and to develop their understanding of different methodologies and research skills. 'Knowledge Boxes' throughout the book provide useful background scientific understanding. Research (described on page 43) shows that teachers often have similar misconceptions about science to the children they teach so, unless you are a science specialist, it is worth spending time checking one's facts!

The first section of this book describes the stages of development that children pass through from birth to 8. It also gives suggestions for the sorts of experiences that adults can introduce to support the development of children's emerging scientific skills, their thinking and their attitudes to science and learning. There are many examples of real children's reactions to the suggested activities and the reader is encouraged to think deeply about the potential value of these experiences. A series of questions is posed, which invite reflection about particular activities and how they can be adapted to ensure maximum learning potential. In particular, the reader is invited to consider which line of questioning is most likely to promote children's reflection and reasoning. In the second section, the author addresses some of the contexts in which emergent science takes place, including the home and the curriculum, and explores the effect of different circumstances, including transition, on the young learner. Again, these are illustrated with relevant case studies, which invite the reader to reflect how they could have had a positive impact in the circumstances described. The final section examines some pedagogical approaches to emergent science, including different types of play, exploration and problem-solving. Again, many real life examples, including a variety of role play scenarios, and simple investigations give the readers plenty of ideas to enrich their own practice.

Throughout the whole book, there is a strong message that the child should be the centre of the curriculum, that good teaching should be based on close observation of, and careful listening to, the child, so that equal importance is given to the ideas of both adult and child as they build a shared understanding. This is contrasted with the top-down and ever-changing demands of the National Curriculum, and a recognition that the pressures of the curriculum mean that even practitioners who argue for a dialogic approach and space for children to create their own meaning are pushed into more didactic modes of teaching. The information contained in this book would certainly help such a practitioner resist these pressures and to teach more confidently in a way that best promotes children's learning.

Hattie (2003) suggests that it takes more than just experience to make an expert teacher; if you want the best outcomes for your children, it is not enough to turn up at work every day for a long time! This book shares a lifetime's experience in emergent science, deeply embedding *what* to teach and *how* to teach it, and *why* a particular approach is effective. If you aspire to be the best teacher that you possibly can be, not only to give your children rich learning experiences, but to be a well informed and articulate advocate for their needs, you could do a lot worse than get hold of a copy of this book and spend some time becoming familiar with the material in it.

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Talking and Doing Science in the Early Years: A practical guide for ages 2-7

By Sue Dale Tunnicliffe. Published in 2013 by Routledge, London, price £19.99. ISBN 978-0-415-69090-4
This review first appeared in NAEE's Environment journal.

The author is a senior lecturer in Science Education at the Institute of Education, University of London. She has dedicated the book to the memory of her eldest son, who showed her '*how young children find out about science'.* Her child-centred approach to teaching and learning stems from this early lesson, reinforced by her young grandsons who have taught her the value of observing and listening to them, and to resist the temptation of telling them all that she knew!

Young children are intuitive scientists, so the role of the adult is to provide the opportunities through which their natural curiosity can lead them into making their own discoveries. By providing them with experiences and appropriate language in these early years, children will better understand scientific theory in later years.

Each chapter focuses on a different aspect of science, and includes numerous activities that encourage young children to observe, question and carry out their own investigations, many of which take place outdoors. Of particular relevance to environmental education are the chapters on *Animals, Plants, Other Living Things (fungi, bacteria and algae), Changes, the Built Environment* and *Outside – the natural environment: soils, sky, weather.*

You don't have to be a science educator to work with young children. You just need to be '*aware of the experiences and observations that there are for the developing child.'* The author does, however, give some useful background information at the beginning of each topic, which she calls '*Big Ideas*'; for example, the topic on *Animals* gives simple explanations about the difference between vertebrates and invertebrates. This section is followed by activities that might be carried out: under '*Talking and Doing*', for example, '*What animals do children see at school, on the way to school, at home, or at a special place they visit?*'

Environmental education is not just about the natural world. Most of us live in an urban environment and the chapter on the *Built Environment* is a valuable reminder to start education about the environment in the immediate locality of where the children live and go to school. As the author says, '*Science begins with observation, then questions … studying the local built environment is an excellent way of developing such skills'.*

This highly practical book will help teachers and parents alike to develop their children's natural curiosity about the world around them … and have fun doing it too!

Sue Fenoughty, NAEE Executive.

Playing and Learning Outdoors: Making provision for high quality experiences in the outdoor environment with children 3-7. 2nd edition

By Jan White. Published in 2013 by Routledge, London, price £17.99. ISBN 978 0 415 62315 5

The aim of this book is to assist practitioners working with this early age group to help these young learners make sense of and experience in a creative, constructive way the everyday world of outside.
It gives realistic and achievable advice, citing appropriate venues and activities that will help these learners construct understanding.

It also provides practical realistic advice and guidelines on equipment and physical play, such as experiencing sand and water and other natural materials, including aspects of the plant world that the children are likely to encounter, as well as acknowledging the importance of construction and den building. At the same time, the author recognises the need to facilitate creative and imaginative play and the addition of the new chapter about providing experiences beyond the garden gate is invaluable.

For practitioners working with emergent scientists, this book complements texts dealing with science and design technology opportunities, although it does not identify them as such.

After an introduction outlining the philosophy, themes and experiences that outdoor play has the opportunity of providing for children, seven chapters follow. Each chapter identifies various aspects of the topic to help extract the most out of the experience that a practitioner can provide, as well as extensive references, including stories, rhymes and suggestions for resources. Chapters conclude with a summary of the main points for quick reference.

The chapters are:

1. Providing for water play outdoors.
2. Providing natural materials outdoors
3. Providing experiences of the living world
4. Providing for physical play and movement outdoors
5. Providing imaginative, creative and expressive play outdoors.
6. Providing for construction play and building dens outdoors
7. Providing play experiences beyond the garden gate.

This book provides another essential resource for early years practitioners, with an invaluable theme of outdoors.

Sue Dale Tunnicliffe,
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