The Journal of Emergent Science

Issue 11 Summer 2016

The Association for Science Education
Promoting Excellence in Science Teaching and Learning

why& how?
PRIMARY SCIENCE TEACHING TRUST

Contents

Issue 11 Summer 2016

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It is free to access for all.

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Editorial

■ Coral Campbell

Welcome to this issue of the Journal of Emergent Science, another great edition highlighting some very interesting research and interesting short pieces of relevance to emergent science.

Firstly, let me explain that the journal is in transition as our new Editors take up their roles. We welcome two new Co-editors, Professor Suzanne Gatt and Dr. Amanda McCrory (see their personal introduction on page 5). Rather than swamp them immediately with the task of writing the Editorial, I have agreed to assist. As one of the Editorial Review Board members, I have been involved with *JES* since its inception and I remember discussing the journal with Jane Johnston and Sue Dale Tunnicliffe at the ESERA Conference in Turkey in 2009.

As an Australian member, I don't get across to the UK or to Europe as often as I once did, but I hope to catch up with some of you at the European Early Childhood Education (ECE) Research Association Conference in Dublin in September. At this Conference, there will be several symposia around science in early childhood:

- STEM teaching in ECE (Session D17)
- Science in early childhood (Session D23)
- Pedagogy of science in ECE (session F7, which contains a presentation by one of the authors represented in this issue, Linda McGuigan)
- The importance of Early Years Science (F12)

Each of these symposia has 3-4 separate papers on ECE research from around the world. In scanning the programme, there are other papers scattered throughout with a science context – often relating to outdoor play, the environment or forest kindergartens (bush kinders, as we call them in Australia).

In Australia and New Zealand, research in science education in early childhood is strong and developing more so each year. New Zealand has had a focus on early childhood research for many years, but the development of our first national Australian ECE framework in 2009 spurred on the support for research in this important area. I am observing also a slow morphing into the idea of STEM (science, technology, engineering and mathematics) educational research, as researchers try to pool ideas and consolidate research funding.

In this edition of *JES*, we have included a number of research articles, a proposal for collaborative research and a call for articles for a special edition of *JES*. One article, entitled *Helping children to express their ideas and move towards justifying them with evidence: A developmental perspective,* by Linda McGuigan, deals with two very important skills for young children, those of reasoning and argumentation. They indicate that children's thinking and response to others are foundational skills. Too often, young children's abilities are underestimated at best, or undervalued at worst. Those of us who have worked with young children can really appreciate the importance of this article for raising awareness of children's capabilities. This article describes what is meant by 'argumentation' but then highlights how the teacher's interactions with children are crucial for developing foundational reasoning and argumentation skills.

Using research-based evidence, the authors provide practical strategies for early childhood practitioners to encourage children's discussion and reasoning.

Another article featured in this issue deals with a little-investigated aspect of chemistry in primary school levels – that of polymeric solids. In *Why does jelly wobble?*, the authors, Dudley Shallcross, Naomi Shallcross, Kathy Schofield and Sophie Franklin, present the outcomes of a workshop for primary school children on the structure and properties of solids. Using the idea that some materials are made up of chains of particles, they found that not only were children receptive to this variation on the conceptual model of solids, but that they were able to build an improved understanding of solids. As a teacher who has found that children's understanding is strongly enhanced through the use of models and representations, I found this paper to be enlightening and I intend to include the authors' ideas in future teaching of solids to pre-service teachers of primary school science.

There is also an interesting article on the knowledge of species in early years children by Meike Mohneke and colleagues, featuring the introduction of a 'researcher's box' by the city of Cologne, Germany. A fascinating piece about the observation and use of mealworms in the primary classroom by Sue Dale Tunnicliffe completes the major articles section.

In this issue, we have a call for research collaboration in the area of gender and socio-economic differences in pre-school science and mathematics. Maria Kambouri, Natthapoj Vincent Trakulphadetkrai and Myria Pieridou, from Reading University and the Open University, present *Exploring children's play-based opportunities for learning science and mathematics through the gender and socio-economic lens – a new research study.* Building on pilot research in Berkshire, they hope to focus the study more broadly and eventually to impact on policy and practice. Many of us are already undertaking research in pre-school science (and mathematics) but, to have impact at the level of policy (and therefore practice), we do need a stronger and more comprehensive research programme.

An important feature in this issue is the call for papers for *JES* 12 (Winter 2016/2017). Entitled *No Boundaries No Barriers – Promoting Creativity*, this special edition will host articles emerging from presentations at the recent PSTT-sponsored International Primary Science Conference held in June 2016. Different types of paper will be accepted, so there is plenty of opportunity for scope to write. It is very valuable to those who cannot make it to these conferences (such as myself) to see the current research. Guidelines and criteria are provided to help you focus on the journal presentation needs.

I would like to thank all the authors who have provided material for this issue of the journal and would encourage readers to consider supporting the journal with future articles. *JES* hosts a range of article types and is the medium through which we can discuss research, develop collaboration and learn.

Enjoy your reading!

Coral Campbell, Interim Editor
Dr. Coral Campbell is an Associate Professor in science education at Deakin University in Victoria, Australia. Her research interests include early childhood and primary science education, teachers' professional learning and children's understandings in science.

Welcome to our new Editors!

We are delighted to welcome the two new Co-Editors of JES, Professor Suzanne Gatt and Dr. Amanda McCrory, who both commenced their appointments on 1st July 2016. We asked them to each write a short piece introducing themselves and outlining how they see the development of this important ASE journal:

Suzanne Gatt writes:

I am Associate Professor in Primary Science and Environmental Education at the Faculty of Education, University of Malta. I am also currently Head of Department of the Department of Early Childhood and Primary Education within the Faculty of Education, which offers national training at Bachelor's level in early years education. I have been working in the education sector for the past 25 years, starting as a physics teacher and moving on to university following further studies in science education. I have studied science education at Master's level at King's College, London and went on to do my PhD at the University of Malta, with Professor Philip Adey as co-supervisor. I now teach at Bachelor, Master and Doctorate level.

I have been working in early years and primary science education for the past 20 years. During that time, I have been involved in many projects and initiatives at European and international level, including the ERASMUS network Science Teacher Education Development in Europe (STEDE); the Comenius 3 – Hands on Science (Hsci); Comenius 2 – The Implementation of Scientific Thinking in (Pre) Primary Schools Settings (STIPPS); FP7 – Creative Little Scientics (CLS); and TEST (which trains and promotes inquiry science). I have also co-ordinated

Suzanne Gatt

the FP7 project Pri-Sci-Net: '*Networking Primary Science Educators as a means to provide training and professional development in Inquiry Based Teaching'* with 17 partners across 14 European countries. Through this project, it was possible to develop inquiry science activities for ages 3-11 years in different langauges and organise teacher training, as well as have the first FP7 project conference within the European Science Education Research Association (ESERA) Conference in Cyprus in 2013.

I am also active within the Commonwealth through the Commonwealth Association for Science, Technology and Mathematics Education (CASTME), having served as Chair of CASTME Europe and now working at national level in Malta. I am active within ESERA, having served as strand chair for a number of the ESERA conferences.

As a science educator, I continue to contribute to science education at early years and primary level through teacher training, research, publications and EU projects. I have a specific research interest in young children's ideas about such science aspects as animals, plants, etc.; inquiry-based learning in science; and story-telling. I am a strong advocate of doing inquiry science with young children.

Taking on the co-editorial role of *JES* is an additional challenge in promoting and supporting science within the early years, with the hope of providing young children with opportunities to develop as scientists and citizens.

Amanda McCrory writes:
I am a lecturer in higher education at UCL, Institute of Education; my roles include the Early Years Foundation Stage (EYFS)/Primary Science and Assessment Lead for the Teach First Programme, London, and the Primary Science Module Lead for the EYFS/Primary PGCE – I currently work with around 500 student teachers, which keeps me on my toes! Prior to this, I worked for 14 years in a number of primary schools in London, during which time I taught from EYFS to Year 6 (age 11) and enjoyed a range of leadership roles. Therefore, I know only too well the demands, but more importantly the rewards, of modern day classroom practice.

From the beginning, my teaching career has been influenced enormously by educational research. I realised early on the importance of being a reflective practitioner, especially if I wanted to be effective in the classroom and make a difference to the lives of the children I was teaching! Educational journals such as *Primary Science* and *JES* played a significant role in my classroom practice, because I could relate to the articles, lay my hands easily on the necessary suggested resources – crucial for the busy classroom teacher – and was simply inspired by the exciting science that was, and continues to be, presented. Learning something new every time I read the journals enabled me to better develop my science subject knowledge alongside my teaching pedagogy, so being part of the editorial team for this journal is an honour.

My research interests lie in the teaching of mathematics, science and socio-scientific issues. I am particularly interested in how research findings in Neuroscience can be used to improve the teaching and learning of maths and science across the primary age range. I am strongly motivated by how those of us in science education can better support teachers to incorporate pertinent research-based teaching strategies and resources that reflect good practice into their teaching, whilst working under the constraints of the current education system. Furthermore, I am concerned with how scientific enquiry and, in particular, child-initiated and child-led enquiry can be promoted to engage all children in being successful 'scientists' in the classroom.

Amanda McCrory

I am thrilled to be the new Co-Editor of this journal alongside my esteemed colleague Suzanne Gatt and am eager to see where our collaboration with the Primary Science Teaching Trust (PSTT) will lead. I am optimistic that we will continue to build on the important work that both Jane Johnston and Sue Dale Tunnicliffe have passionately facilitated.

Unequivocally, it is my aspiration that this journal will continue to promote effective, yet exciting, early years science practice and leadership whilst inspiring readers to undertake their own practitioner research, providing a platform through which they can share their research experiences and outcomes. This is crucial, as it is in the classroom where ultimately we all wish an impact to be made.

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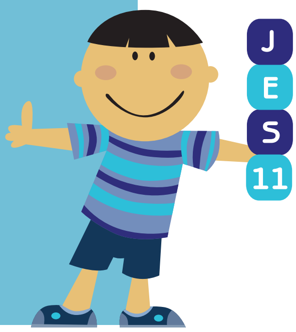

Contributing to the Journal of Emergent Science

About the journal

The *Journal of Emergent Science (JES)* was launched in early 2011 as a biannual e-journal, a joint venture between ASE and the Emergent Science Network and hosted on the ASE website. The first nine editions were co-ordinated by the founding editors, Jane Johnston and Sue Dale Tunnicliffe, and were the copyright of the Emergent Science Network. The journal filled an existing gap in the national and international market and complemented the ASE journal, *Primary Science*, in that it focused on research and the implications of research on practice and provision, reported on current research and provided reviews of research. From Edition 9 in 2015, *JES* became an 'open-access' e-journal and a new and stronger Editorial Board was established. From Edition 10, the copyright of *JES* has been transferred to ASE and the journal is now supported by the Primary Science Teaching Trust (PSTT).

Throughout the changes to *JES*, the focus and remit remain the same. *JES* focuses on science (including health, technology and engineering) for young children from birth to 11 years of age. The key features of the journal are that it:

- is child-centred;
- focuses on scientific development of children from birth to 11 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

The Editorial Board of the journal is composed of ASE members and PSTT Fellows, 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.

Contributing to the journal

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 in length 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) 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

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.

Call for papers JES Issue 12 (Winter 2016/17)

Contributions are welcome for The Journal of Emergent Science (JES) Special Edition: No Boundaries No Barriers – Promoting Creativity

This special edition of *JES* will include articles emerging from papers presented at the inaugural PSTT-sponsored International Primary Science Conference held in June 2016.

It is anticipated that there will be three different types of paper:

- Empirical Research Paper (reporting on a study focused on primary education);
- Theoretical Paper (making conceptualised suggestions related to primary education); and
- A scholarly report of a 'session' (perhaps a panel discussion or a practical workshop written up in an easily accessible, but academic, style).

All potential authors are encouraged to consider submitting their papers to ensure they fulfill the following general criteria (more specific guidelines for each type of paper can be found below). Articles should focus on any of the key themes of the Conference, including:

- Outdoor learning
- STEM pedagogy and learning
- Early years education
- Professional Development
- Research into practice

The Editors would especially welcome articles related to some form of creativity in primary science.

It is expected that the general features for publication will apply; however, for this special edition, the transition between Key Stages 2 (age 7-11) and 3 (11-14) will also be included. Articles can be focused on the following within the themes listed above:

- Science, technology, engineering (or mathematics within science) education;
- The education of young children from birth to 12 years of age;
- Child-centred learning;
- Teacher practice or pedagogy; and
- Professional development of science teachers.

Articles should be clearly written and provide evidence-based claims or findings. The Guest Editor for this special edition is Professor Deb McGregor (please contact at dmcgregor@brookes.ac.uk for further information).

Please send all submissions to:
janehanrott@ase.org.uk in an electronic form (as a Word (97 – 2004) .doc file.
The deadline for inclusion in this special edition is 1st October 2016.

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. Full-length papers of up to 5000 words, as well as shorter reports or articles of up to 2500 words, are acceptable.

Specific guidance for the three types of article requested:

Empirical Research Paper (5000 words):

1. Abstract:
   synopsis of article (about the study – try not to reveal all the 'outcomes' until the end of the paper. This should clearly 'signpost' the most important aspects of the project).

2. Introduction:
   a. Why is this 'work reported on' important?
   b. What is already known about this area of work?

3. Methodology and methods:
   a. What did you do?
      i When
      ii Whom
      iii How
      iv Issues (ethics)
      v Consider whether any research 'tools' could be simplified and shared – in Appendix?

4. Findings:
   a. What data/evidence do you have? Present in Harvard format (so readers can tell from looking at table/graph what it means without needing the text)
   b. What does the data/evidence mean? ...and for whom?

5. Discussion:
   a. Why are the findings important?
   b. What do they mean for practitioners? Children? Heads? Governors?

6. References

7. Appendices
   a. Any research instruments that might be useful for others? E.g.: questionnaire, interview questions.

Theoretical Paper (3000 words):

1. Abstract:

2. Introduction:
   a. Review of existing studies (Borko & NSLC)
      i What is missing (that is in your arrow model)?
   b. Why is this model/theory needed...?
   c. How does it relate to other theories out there (Schon/Dewey/Van Mannen)?

3. Define your model...
   (go back to seminal authors to justify characteristic/features)
   a. Developing CPD literacy

4. Conclusion:
   How it can be used (context – for designing/reflect on CPD, etc. etc.)

5. References

Discussion paper *(2500):*

1. Abstract

2. Introduction

3. Description and discussion of the session observed

4. References

For general guidelines on written style, please see page 7

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Explorative study about knowledge of species in the field of early years education

■ Meike Mohneke ■ Faisa Erguvan ■ Kirsten Schlüter

Abstract

The city of Cologne introduced a 'researcher's box' for 'small natural scientists' in day-care facilities to help children learn about nature. In this study, we investigated the current state of the children's understanding of nature and their species knowledge before the introduction of the researchers' box. Moreover, we examined which factors are positive or negative drivers for children's knowledge.

Children aged 4 and 5 in day-care facilities in Cologne were questioned. The following factors were examined regarding their effect on the experience and knowledge of species and the environment:

- social milieu
- migration background
- age
- gender, and
- children's preference for being in nature.

The children were best at identifying small animals, but hardly knew anything about trees. The main effect was the migration background of the children, followed by the social-economical milieu and age.

Since the present study detected deficiencies concerning children's encounters with nature, species knowledge and their sense of responsibility towards nature, the application of the researcher's box could be directed specifically to compensate for these deficiencies.

Keywords:
children, kindergarten, pre-school, species knowledge, responsible behaviour

Introduction

A healthy environment is essential for the health and wellbeing of our human species (Kellert, 2005). Thus, nature's destruction, pollution and decline endanger not only natural habitats and the organisms living in them, but also, by implication, the human species. It is therefore highly important to arouse a broad awareness for the environment and biodiversity (Gebhard, 2013). A first step towards this is an effective education about nature and its protection, including environmental issues and biodiversity, and knowledge about species in particular. With this in mind, the city of Cologne planned to introduce a 'researcher's box' for 'young natural scientists' in day-care facilities. This resource aims to sensitise children of a very young age to the natural environment surrounding them and the organisms living within it. In an engaging way, it helps children to learn about *fauna* and *flora* in surrounding ecosystems by providing tools such as binoculars and bug eye viewers to identify both plant and animal species, and tools to increase biodiversity in the surroundings of the day-care facilities, such as wildflower seeds and components with which to build bird boxes. Furthermore, it provides literature for the children, with illustrations about common native organisms and guidance for the nursery nurses on how to use the materials in the box.

Theoretical background

Many species of the native *fauna* and *flora* are unfamiliar to both children and adults (Lindemann-Matthies, 2002). Due to the current decline of biodiversity and species' richness (e.g. Butchart *et al*, 2010; Pereira *et al*, 2010; Pimm *et al*, 2014), it is essential to educate people about the value of the biodiversity of organisms, including less 'attractive' ones such as plants and invertebrates, as well as their protection, from an early age (Kellert, 1996).

Generally, in the case of the disinterest in nature of the youngest children, a subsequent disinterest of adolescents is anticipated (Kellert, 2007). Hence it is recommended that we encourage the children's interest in nature up to the 1st grade (age 6) and to maintain it over subsequent years to avoid a drastic decline of interest during adolescence (Kellert, 2007). People who had more experiences of nature during their childhood are more likely to have pro-environmental attitudes, which may further influence their pro-environmental behaviours (Leske & Bögeholz, 2008; Cheng & Monroe, 2010). Earlier studies have detected strong relationships between children's outdoor experiences and their conservation values later in life (Larson *et al*, 2009). Therefore, children should experience nature as an integral part of their everyday lives. Lindemann-Matthies (2002) describes the programme 'Nature on the Way to School', which aimed to increase children's everyday-life perception of plants and animals. In fact, after participating in the programme, children were able to name more individual organisms and they also noticed more plants and animals than before (Lindemann-Matthies, 2002). Schwier (2001) mentioned that, firstly, learning about plants and animals helps children to reduce their distance from nature's *fauna* and *flora*; secondly, they will learn that, by observing and identifying species, nature can become a familiar part of their everyday lives and, thirdly, this sets the course for respecting and protecting nature. In general, the relationship to a living thing that one is able to recognise and identify is more intensive and respectful than that with an unknown organism. Thus, species knowledge leads to a responsible way of acting (Mayer, 1992).

In this sense, the Cologne 'researcher's box' is expected to essentially contribute to a healthy development of the children by encouraging activities outdoors on the one hand and a respectful interaction with nature on the other.

To allow a later evaluation of the effectiveness of the box, this pre-study was done beforehand and was meant to determine the children's status of knowledge and experiences of and with nature and species before the box's introduction. It is the goal of this study to present a *status quo* of the children's understanding of nature, their experiences in and with nature, their species knowledge and their responsibility towards nature and living beings.

With its findings, this study contributes to environmentally-oriented teaching in the kindergarten, particularly taking into account specific factors (social-economical milieu, migration background, age, gender, and preference for being in nature), which can affect children's approaches to nature. In cases where educators are aware of those factors that can influence the children's approach to and knowledge of nature, they are able to better commit themselves to teaching and bringing the children closer to nature.

Methodology

A questionnaire relating to the children's experiences with and knowledge about nature was used in day-care facilities for children in Cologne, Germany. The project involving a 'box for naturalist scientists' was initiated by the Office of Environmental and Consumer Protection of the city of Cologne. Hence, the city chose the day-care facilities to be investigated in this study. The study was carried out with the permission and assistance of the city of Cologne. City representatives also jointly agreed upon the wording of the questionnaire. Only children whose parents agreed in writing were questioned.

Furthermore, the questioning was optional and the children were able to withdraw at any time. Agreement from the local ethics commission was not necessary since, apart from the children's mother tongue, no sensitive data were raised during the survey. The questioning was carried out anonymously.

Socio-economical milieus: Sinus-Milieus based on the microm data analysis:

To analyse the possible impact of socio-economic status on the children's knowledge of and experiences in nature, we had to classify the day-care facilities using a certain key. We referred to the *Sinus-Milieus,* which we received from the microm Micromarketing-Systems and Consult GmbH. These milieus are based on data referring to various households in a certain district, its members, and the environment (Küppers, 2005):

- geographical information (e.g. location of the urban district, type of house/street);
- economic information (e.g. social status and professional qualifications of the members of the household); and
- demographical information (e.g. age, head of household, and probability of single households).

According to this information, the classification of the milieus occurs in three main categories: upper, middle, and lower *Sinus-Milieu.* Each urban district is described by the proportion of the 3 different *Sinus-Milieus* to which its inhabitants belong. In order to assign each day-care facility to just one milieu, we used an allocation formula based on a 40% limit set by us. In the case where the limit of 40% is exceeded by the upper or the lower milieu, the day-care facility is classified towards this respective *Sinus-Milieu.* In the case where the 40% limit does not get exceeded, the day-care facility is classified towards the middle *Sinus-Milieu.* Based on this classification, the study includes: 20 children whose day-care facility is located in the upper *Sinus-Milieu;* 52 children whose day-care facility is located in the middle *Sinus-Milieu;* and 20 children whose day-care facility is located in the lower *Sinus-Milieu.*

Study implementation

The survey was conducted in June and July 2013, just before school holidays started. In total, 92 children from 27 day-care facilities from 21 different urban districts were interviewed and included in this study. Every child was questioned individually in a separate room in the day-care facilities by one of the authors. The length of the questioning was between 20 and 45 minutes each, depending on the talkativeness of the children. In each day-care facility, between one and five children were questioned. This difference in the number of children questioned was due to various reasons, such as absence because of illness or missing parental agreement letters. At the time of the investigation, the children interviewed (n=92) were between four (n=44) and five (n=48) years old (mean age=4.52; SD ± 0.50), and 55.4% were boys (n=51) and 44.6% girls (n=41). Thirty-seven (40.2%) of the children questioned had a migration background. Seventeen different foreign countries of origin were identified, with Turkey (13%) being the most frequent.

Questionnaires

To allow a standardised comparison of the children's knowledge before and after the introduction of the 'researcher's box', questionnaires comprising mainly closed questions were used to interview the children. We chose closed questions for better comparability of the data, because subsequent measurement of the gain of knowledge was intended after the introduction of the 'researcher's box'. One important criterion for the content of the questions was that they should be linked to the content of the 'researcher's box'. Hence the names of living beings we asked for referred to those listed among other species in the accompanying book for the kindergartners. The questions used simple phrasing and were supported by the use of pictures to make the questioning understandable, vivid and interesting for the children.

The questionnaire encompassed questions concerning demographic data (age, gender and migration background). Those variables have been shown to be significant factors for knowledge in former studies (LBS Kinderbarometer Natur, 2005; Brämer, 2006). The geographical locations of the respective day-care facilities were also recorded in order to obtain socio-demographic criteria.

Questions that addressed the general knowledge of species usually employed the use of photographs or pressed samples. Each picture was accompanied by two questions linked with each other. The first question addressed whether the children knew the organism presented, which meant that they had noticed it in nature; the second asked the children to specify their knowledge by mentioning the common name of the organism. Examples of the questions include:

'Do you know the tree these leaves come from?', *'What is the name of the tree?'*, *'Do you know this flowering plant?'*, and *'What is the name of this plant?'* Even though the first question was a good way to start, its evaluation was considered to be critical, because the validity of the children's answers could not be proven. Only by naming the plant could familiarity be detected. Therefore, the results presented will refer to the latter type of question. Species included in the questionnaire were chosen according to the content of the 'researchers' box' as well as their noticeable appearance and/or to their frequent occurrence in the local area in which this study was conducted. The questionnaire therefore comprised questions that asked for species' names (such as dandelion and daisy, or blue tit and great tit) and further questions that asked for names of an animal class (such as spider and snail). This choice of samples was further based on how children actually encounter specific plants and animals. In the everyday life of children (and usually adults as well), certain animals and plants are recognised on class- or family-level and do not get further classified.

The last question aimed to ascertain children's knowledge of species-appropriate handling and their ability to empathise with the living situation of living organisms.

Data analysis

The children's answers were most often coded by numbers in a dichotomous way (e.g. 1 = correct species' name, 0 = incorrect name or no answer) to be able to subsequently conduct a statistical analysis with the data. First of all, we looked at the frequencies of the obtained variables as well as medians and the distribution of quartiles and the respective means and standard deviations. Non-parametric tests were applied to examine whether there were significant differences concerning the investigated factors: upper, middle, and lower *Sinus-Milieu;* with/without migration background; age (four and five years old); and gender. Apart from the *Sinus-Milieu* factor, which was tested with a Kruskal-Wallis Test (Kruskal & Wallis, 1952), the factors were analysed by applying the Man-Whitney-U-Test (Mann & Whitney, 1947). In addition to tests for significance, the respective effect size was determined too. This statistical analysis was done with the program SPSS (Statistical Package for the Social Sciences, version 21).

Results

In total, 79 children have direct access to nature close to their home. Fifty-six of those children 'own' a garden and 23 have a green area in close proximity to their home. Only eleven children answered that they neither had a garden nor a green area close to their home.

Nature encounters

The children were asked about their different experiences in and with nature. We assumed that the children mentioned all encounters that they could remember. Items referring to nature activities found in a survey by Braemer (2006) were adopted and integrated in our own questionnaire. On average, the children (n=92) had 13.53 (SD ±2.72) from a total of 17 encounters with nature. In total, 13 activities were experienced by more than 70% of the children (climbing a tree, observing a bird, picking a flower, touching small animals, touching a earthworm, jumping in a pile of leaves, petting a larger animal, planting a plant, balancing on a tree trunk, harvesting fruits and/or vegetables, seeing a living cow, collecting herbs, and visiting a wildlife park); 3 activities by more than 50% of the children (being on a farm, splashing in a lake, or seeing a hedgehog) and only one activity by just 41% of the children (building a hut in the woods).

Species knowledge

Figure 1 shows which species of plants and animals the children have known. Often the children recognised a species, but did not know the name. 'Recognising' means that a child claims to know an animal or a plant when a photograph or pressed plant sample is shown to him or her. The children showed the most knowledge in specifying small animals, followed by flowers and birds. However, only a minority of the children could name trees.

Responsible behaviour

Figure 2 shows the frequency distributions concerning the children's interpretations of different scenarios showing animals in natural and unnatural environments. The first picture showed birds sitting in a birdhouse with food and snow, which should imply that the birds are fine while being in their natural environment in winter, profiting by the subsistence aid in terms of an additional food

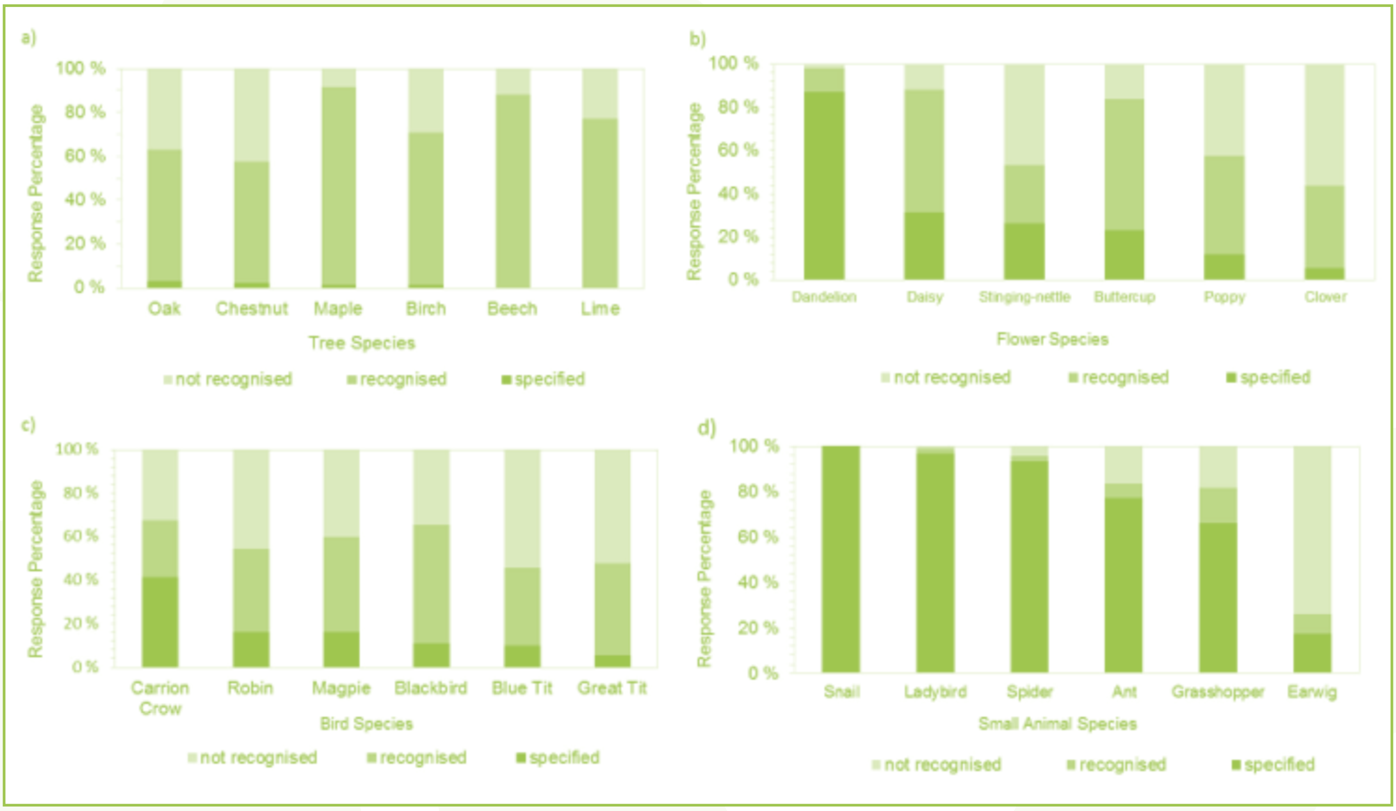

Figure 1: Species knowledge of a) trees; b) flowers; c) birds, and d) small animals. (The children were shown pictures of different plants and animals and asked if they knew what the animal/plant was. The respective species are given on the x-axis and the corresponding response percentages of the children on the y-axis.)

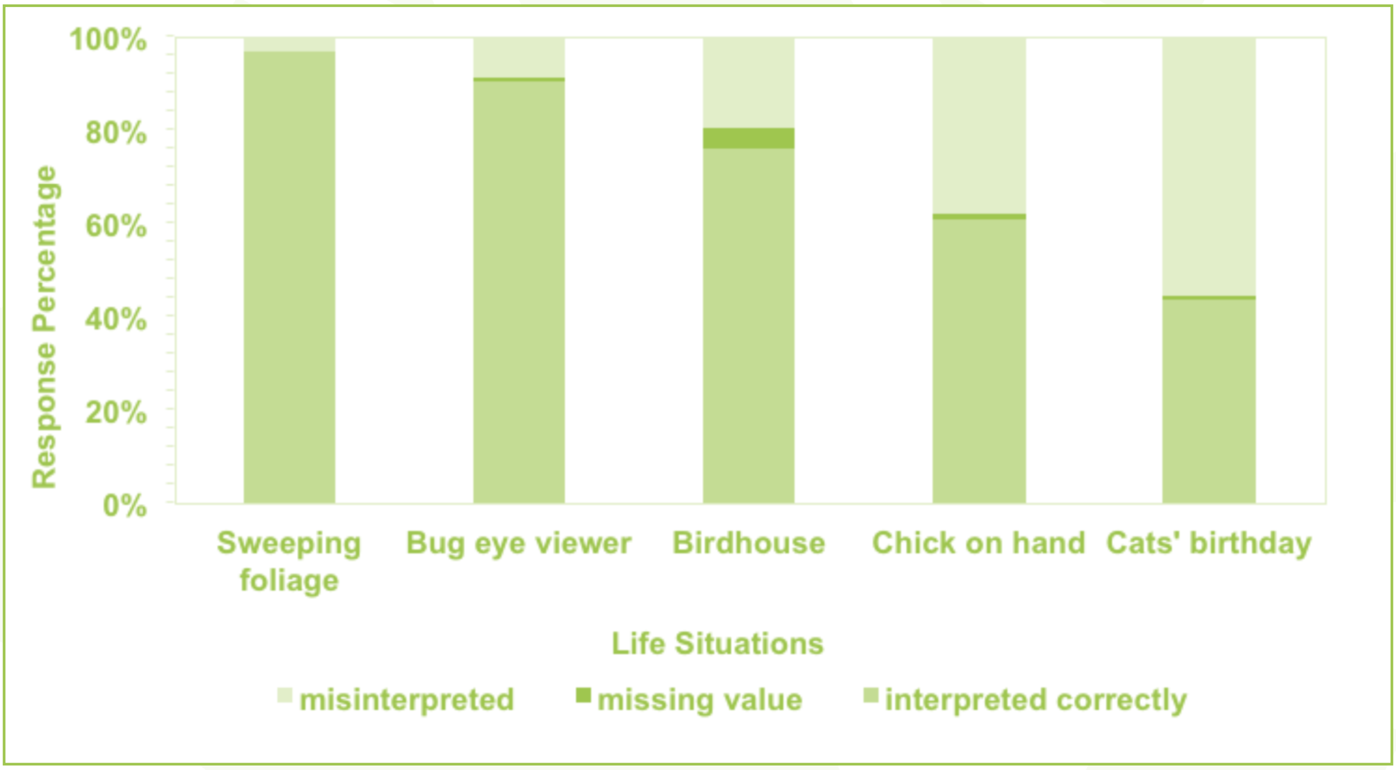

Figure 2: Presentation of species-appropriate, as well as inappropriate, life situations (Interpretations of Life Situations). (The children were presented with photographs of different life situations of different animal species (given on y-axis) and were asked to say if the respective life situation is appropriate to the respective species, or not. The response percentages of the children are given on the x-axis. Missing values are used when the respective children did not have an opinion towards the displayed scenery and answered with '*I don't know*'.)

source. The majority of the children had the same impression. However, 18 out of 92 children thought the situation was bad for the birds, because they must be cold. The second picture showed a cat with a party hat in front of a birthday muffin. Obviously, this cat was not in its natural environment. However, the majority of the children thought this situation would be good for the cat, since it was its birthday. Some of the children who understood that this cat was not fine also realised that the situation is not species-appropriate, as a muffin is not cat food.
A bird chick in a hand of a human was interpreted correctly as not good for the bird by the majority of the children. But 35 thought that the chick was doing fine in the hand, as it could rest and sleep. The next picture showed a bug eye viewer with two frogs inside, which should imply that the frogs were not in their natural environment and hence were not fine. The majority of 83 children interpreted the situation correctly, whereas 8 thought that the frogs were fine but could not say why. The last picture showed a man piling up foliage. The question addressed the small animals living in and under the foliage, who would have been heavily disturbed by this action. Eighty-three children found that the piling up of the foliage was bad for the animals living underneath. Only three thought that it was good for the animals, but were not able to explain why.

Factors effecting children's knowledge

In this study, we investigated the following factors regarding their effect on the experience and knowledge of nature and species:

- *Sinus-Milieu*, representing the socio-demographic environment in which the children live;
- Migration background;
- Age (4 or 5 years old);
- Gender; and
- Their preference for being out in nature (high or middle/low).

Regarding the last point, the questionnaires revealed that most children (n=64) like to be in nature, which means they have a high preference for nature, whereas a total of n=28 children said they only like it a bit (n=21) or not at all (n=6), meaning these have a low preference for nature. The two categories, 'like a bit' and 'do not like' were pooled together in order to receive a higher 'n' for the statistical analysis. Table 1 shows the results concerning the different factors and their effect on children's encounters with nature, their species knowledge and their respectful behaviour towards living organisms. The migration background of the children showed the main

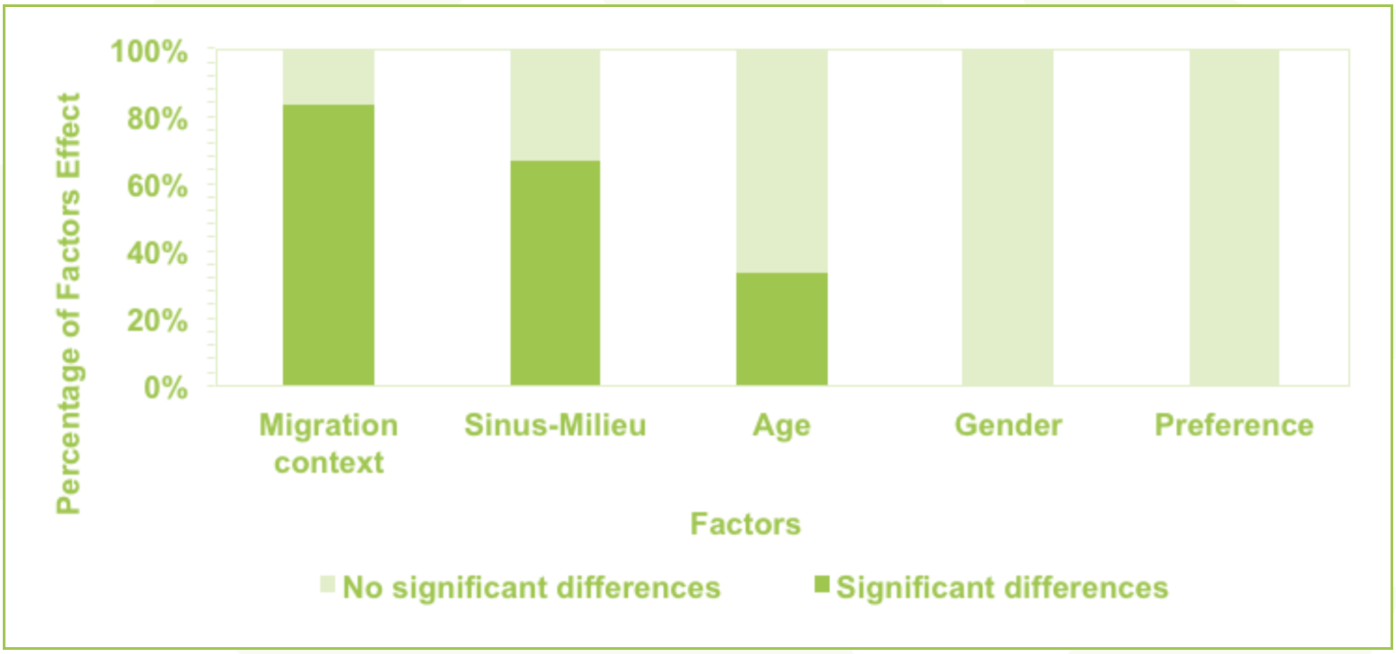

Figure 3: Factors affecting children's knowledge. (The Figure shows the degree of the effect of different factors (showing on the x-axis). Those factors were investigated regarding their effect on the species knowledge (4 categories) of the interviewed children, their interpretation of species-appropriate life situations and their encounters/experiences with/in nature.)

Variables		Sinus-Milieu			Migration Background		Age		Gender		Preference	
Categories		lower	middle	upper	without	with	4	5	m	f	high	middle/low
Sample Size		n 20	n 52	n 20	n 55	n 37	n 44	n 48	n 51	n 41	n 64	n 27
Nature encounters												
	M / SD	12.70 / 3.1	13.40 / 2.77	14.70 / 1.72	14.26 / 2.47	12.46 / 2.75	13.75 / 2.49	13.33 / 2.92	13.31 / 2.79	13.81 / 2.63	13.56 / 2.66	13.59 / 2.86
	Md	13.0	14.0	15.0	15.0	12.0	14.0	14.0	14.0	14.0	14.0	14.0
		p = 0.090, χ^2 = 4.809, df = 2, r = 0.229			p = 0.001, U = 614, z = -3.242, r = -0.338		p = 0.625, U = 994.0, z = -0.489, r = -0.051		p = 0.426, U = 945.0 z = -0.797, r = -0.083		p = 0.816, U = 837.5, z = -0.232, r = -0.024	
Species knowledge:												
Trees	M / SD	0	0.12 / 0.38	0.05 / 0.22	0.13 / 0.39	0	0	0.15 / 0.41	0.12 / 0.38	0.02 / 0.16	0.08 / 0.27	0.07 / 0.39
	Md		0	0	0			0	0	0	0	0
		p = 0.320, χ^2 = 2.278, df = 2, r = 0.157			p = 0.039, U = 906.5, z = -2.066, r = -0.215		p = 0.016, U = 0.924, z = -2.412, r = -0.252		p = 0.155, U = 968.0 z = -1.423, r = -0.148		p = 0.505, U = 831.0 z = -0.667, r = -0.07	
Flowers	M / SD	1.15 / 1.04	1.83 / 1.41	2.85 / 1.6	2.22 / 1.44	1.43 / 1.44	1.61 / 1.26	2.17 / 1.63	1.63 / 1.2	2.24 / 1.73	1.8 / 1.57	2.19 / 1.27
	Md	1.0	1.0	2.5	2.0	1.0	1.0	2.0	1.0	2.0	2.0	1.0
		p = 0.001, χ^2 = 14.409, df = 2, r = 0.396			p = 0.002, U = 639, z = -3.14, r = -0.327		p = 0.108, U = 858.5, z = -1.609, r = -0.168		p = 0.094, U = 841.0, z = -1.674, r = -0.175		p = 0.067, U = 661.0 z = -1.835, r = -0.191	
	Post hoc	lower « upper: p < 0.001, U = 71.5, z = -3.571, r = -0.372 middle « upper: p = 0.005, U = 307.5, z = -2.795, r = -0.291										
Birds	M / SD	0.40 / 0.82	0.92 / 1.12	1.80 / 1.47	1.31 / 1.3	0.54 / 0.96	0,80 / 1.13	1.19 / 1.3	1.12 / 1.31	0.85 / 1.13	0.94 / 1.28	1.11 / 1.12
	Md	0	0.5	1.0	1.0	0	0	1.0	1.0	0	1.0	0
		p = 0.001, χ^2 = 14.182, df = 2, r = 0.393			p = 0.001, U = 641.5, z = -3.205, r = -0.334		p = 0.121, U = 870.5, z = -1.552, r = -0.162		p = 0.317, U = 926.5, z = -1.001, r = -0.104		p = 0.316, U = 756.5, z = -1.002, r = -0.105	
	Post hoc	lower « middle: p = 0.049, U = 379.5, z = -1.969, r = -0.205 lower « upper: p < 0.001, U = 72.0, z = -3.679, r = -0.3836 middle « upper: p = 0.011, U = 326.5, z = -2.55, r = -0.2659										
Small Animals	M / SD	4.25 / 0.91	4.33 / 1.17	5.25 / 0.79	4.71 / 1.08	4.22 / 1.08	4.23 / 1.2	4.77 / 0.96	4.65 / 1.02	4.34 / 1.2	4.48 / 1.1	4.56 / 1.16
	Md	4.0	5.0	5.0	5.0	4.0	4.5	5.0	5.0	5.0	5.0	5.0
		p = 0.001, χ^2 = 14.189, df = 2, r = 0.393			P = 0.017, U = 734.0, z = -2.393, r = -0.25		p = 0.024, U = 784.0 z = -2.254, r = -0.235		p = 0.252, U = 908.0, z = -1.145, r = -0.119		p = 0.642, U = 813.5, z = -0.464, r = -0.048	
	Post-hoc	lower ↔ upper: p = 0.001, U = 79.5, z = -3.443, r = -0.359 middle ↔ upper: p = 0.001, U = 273.0, z = -3.321, r = -0.3462										
Responsible behaviour												
	M / SD	3.35 / 1.14	3.62 / 0.87	4.15 / 0.88	3.82 / 0.88	3.46 / 1.04	3.68 / 0.91	3.67 / 1.02	3.82 / 0.95	3.49 / 0.95	3.69 / 0.92	3.74 / 0.94
	Md	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.0	4.0	4.0
		P = 0.047, χ^2 = 6.116, df = 2, r = 0.258			p = 0.144, U = 843.0, z = -1.461, r = -0.152		p = 0.873, U = 1036.5, z = -0.16, r = -0.017		p = 0.076, U = 830.5 z = -1.776, r = -0.185		p = 0.913, U = 852.0, z = -0.11, r = -0.012	
	Post hoc	lower ↔ upper: p = 0.035, U = 122.5, z = -2.191, r = -0.2284 middle ↔ upper: p = 0.03, U = 356.5, z = -2.164, r = -0.2256										

Table 1: Effect of the investigated factors / variables (*Sinus-milieu*, migration background, age, gender, preference of being in nature) on nature encounters, species knowledge, and awareness of species-appropriate behaviour. (Given are the results of the Man-Whitney-U-Test and the Kruskal-Wallis Test, including the level of significance, the relative test statistic, standardised test statistic z, the effect size r. Significant results ($p<0.05$) are highlighted with a tint. (Abbreviations: M = Mean, SD = Standard Deviation, Md = Median))

effect, followed by the *Sinus-Milieu* and age. Gender and preference of being in nature had no effect at all. The main effects were detected for species knowledge. Concerning the responsible behaviour of the children, it was only affected by the *Sinus-Milieu* of the day-care facility in which the children were categorised.

Besides the significance p, we also report the effect size r (Cohen, 1988). Regarding species knowledge, a medium effect was found for the *Sinus-Milieu* factor, a small to middle effect for the migration background factor and, in some cases, a small effect for the age factor. In addition, the migration background factor had a medium effect on nature encounters and, concerning children's responsible behaviour, a small effect was detected for the *Sinus-Milieu* factor. In general, the effect sizes for the *Sinus-Milieu* were slightly higher than for the migration background. A huge effect above the 0.5 criterion has not been detected.

Discussion

Nature encounters

The data elicited by the questionnaires give a good impression of the relationship that these children of kindergarten age have with nature today. Even though the children live in one of Germany's biggest cities, Cologne, the majority have access to nature in terms of their own garden or green areas close to home. Moreover, the majority of the children included in the study have experienced already most of the anticipated encounters with nature that were addressed in the questionnaire. A former study by Cheng and Monroe (2010) detected a significant correlation between children's connection to nature and nature near their homes. Hence, the majority of the children interviewed possessed a positive living situation in which to further connect with nature and develop an interest in environmentally friendly practices. However, although nature encounters are already high for the children included in this study, these experiences should be offered to every child.

Species knowledge

An aspect that has to be taken into account for the validation of the results is the response behaviour of the children (Kiegelmann, 2010). The impression was that the majority of the children certainly answered the questions honestly. However, the answer categories 'specified' and 'not recognised' are in general more meaningful and offer a better base upon which to draw conclusions, whereas the category 'recognised' indicates some doubt and the possibility that the child does not in fact know the respective species. There were certainly some children who tried to give the desired answers in this sense in that they would claim to recognise all species. On the other hand, there are also some children who became tired of the questionnaire (minimum length between 20-30 minutes) and would always respond *'no, I do not know'*. We are aware of the presence of those factors and their effect on the children's answers. Additionally, children from a migration background could be disadvantaged, as they might know a specific species and its name in their mother tongue, but not necessarily in the German language.

The main findings of this study regarding the children's species knowledge are as follows:

- Knowledge of small animals was the highest, followed by that of flowers, birds and trees.
- Tree species were rarely specified, and beech and lime not at all. The fruits of the trees were not included in the questionnaires, which could have possibly influenced the results, as they might be more familiar to the children.
- Knowledge of flower species was relatively high in these children in comparison to that of tree species (but low in comparison to that of small animal species). The reason for this positive result could be that the flower species included in the questionnaires were mainly species that occur in very high frequencies, even in urban areas, and hence can easily be recognised by the children, such as dandelion and daisies.
- In contrast to the knowledge of small animal species, the knowledge of birds seemed to be rather low. Also Huxham *et al* (2006) stated that species knowledge of birds is constantly low in children over the years, although birds are easily encountered.
- In general, the results of this study show that species that the children can easily encounter, such as some common arthropod species and certain flower species that they

- come across regularly, are better known than bird or tree species. This finding is in accordance with Patrick *et al* (2013), who stated that the personal experiences and first-hand encounters of children are vital as they construct their knowledge of species.
- Regarding the last point, we also have to take into account that the identification of small animals occurred on a higher taxonomic level (up to classes), whereas the identification of tree and bird species occurred on species' level and thus was more demanding. This could have led to the better results regarding the identification of small animals.

The introduction of the 'researchers' box' might be a useful method to eventually raise the children's interest in those 'unknown' species, such as trees. As an introduction to species knowledge, species that are already known to the majority of the children should be chosen in order to build on existing knowledge and interest. On this basis, subject areas should be chosen in which the children's knowledge is low, such as tree species. A successful start to learning about tree species might be to get to know their fruits, and subsequently their leaves. The advancement of the linguistic skills of the children should be another focus, in order to enable the children to exchange their knowledge about species and to talk about their activities in nature.

Responsible behaviour

The last interview question addressed the children's interpretation of different animal life situations. The aim of this question was the analysis of the children's ability to interpret the situations that were species-appropriate. The answers can be distinguished between the children's empathy and sense for species-appropriate behaviour. In most cases, the majority of the children gave the correct interpretation. However, many children misinterpreted the situation of the cat at the birthday party as being species-appropriate. Here, the children were probably not able to actually differentiate between the cat as an animal and themselves, and an actual knowledge about species-appropriate treatment did not yet exist for most children. In all cases, the majority of the children showed sympathy and, to some degree, empathy with the animals in the respective life-situations. Sympathy and empathy are generally affective factors influencing pro-environmental behaviours (see Cheng & Monroe, 2010). Moreover, children who enjoy nature usually have empathy for other living organisms and feel responsibility. Therefore, ways to promote children's empathy with animals living free in their natural habitat should be explored and correct handling should be practised – or at least discussed. Species-appropriate behaviour should be fostered as soon as children are able to distinguish between their own feelings and desires and those of animals and living organisms in general.

Influencing factors

- Migration background has been shown to be the most affecting factor influencing species knowledge and children's experiences in and with nature, followed by the socio-economic factor. In accordance with our findings, the LBS-Kinderbarometer (2005) stated that children with a migration background experience nature less often than native German children. Native German children are more often allowed to be alone outside and to explore their home environment than children with a migration background. Furthermore, native German children mentioned having their own garden more often than the children with a migration background (based on data revealed by the present study). Thus, the better access of German children to nature could lead to a better connection with nature (Cheng and Monroe, 2010). The socio-economic factor is said to have an indirect influence on school performance (Rost, 2001). In our study, the influence of the milieu could mirror and substantiate respectively the effect of the migration background and vice versa. Urban districts, which we have categorised to the lower *Sinus-Milieu*, also hold a comparatively high frequency of inhabitants with a migration background (Amt für Stadtentwicklung und Statistik der Stadt Köln, 2012). Moreover, in cases where both factors affected species knowledge, the *Sinus-Milieu* was seen to have a higher effect size. Hence, its effect on species knowledge has more weight than migration background.

Another aspect that has to be taken into account is that children with a migration background possibly have language deficiencies. Those children might have known the names of the animals and plants in their mother tongue. However, we were not able to check on this aspect in the scope of this study, due to the high number of different mother tongues involved. We propose that improved language skills will permit the children with disadvantaged living circumstances to obtain a better precondition to learn about nature and to subsequently develop a responsible consciousness for nature.

- The effect of the age factor is not remarkable, since we assumed that older children would have better species knowledge. Earlier studies have shown that children's interest in biology increases until the beginning of adolescence, from whence it declines significantly (Löwe, 1992; Randler, 2008). Hence, with the increase of interest, an increase in knowledge would be anticipated also with younger children. This effect seems to be smaller with kindergarteners.
- Gender is not an influencing factor in this study. This finding is in accordance with Hasselhorn and Gold (2013), who stated that the school performance in biology of girls and boys shows no significant difference. Accordingly, Randler (2008) pointed out that gender differences seem marginal and overestimated in the specialist field of species knowledge. Other studies detected gender differences, with girls showing more interest in biology (Löwe, 1992; Killermann, 1998; Randler, 2008) and a better species knowledge (Lindemann-Matthies, 2002). However, those studies generally focused on older school children.

Conclusion

This study is a valuable contribution to an environmentally-oriented education in the kindergarten. We showed that the migration background and social-economical milieu of children are both factors that affect their experiences with and knowledge about nature and, furthermore, their ability to recognise species-appropriate behaviour. Therefore, we would suggest that the encouragement of outdoor experiences and transmission of knowledge about nature should be addressed as early as possible. The ability to communicate and exchange experiences and knowledge will possibly encourage and motivate the children to further interact with their surrounding natural environment and biodiversity. Furthermore, environmental education should include ethical reflections and orientation for action (for example, concerning species-appropriate behaviour) as recommended by Gebhard (2013). The willingness to act to conserve biodiversity is influenced by the interest in and knowledge about nature, as well as exploring and ecological experiences (Leske & Bögeholz, 2008). Thus, due to the problems that the Earth is threatened with today, an environmentally-oriented education promoting a respectful attitude to nature and living organisms from an early age should be an overall concern. The 'researcher's box' represents a valuable resource to address those aspects of an environmentally-oriented education. It can be used to increase species knowledge and to learn about the importance of biodiversity. The proposed activities offer the possibility to experience nature and also to address ethical topics, leading to a responsible attitude and behaviour towards nature. However, to optimise the best use of the 'researcher's box' will require motivated nursery teachers who are themselves interested in biodiversity and environmental issues. Therefore, a further study is proposed to follow the present one in order to investigate the opinions and dedication of the nursery teachers.

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Observing mealworms in the primary classroom

Sue Dale Tunnicliffe

Why look at animals in class?

There is a partnership in science education – between teachers and their pupils. The teacher is alert to opportunities for developing pupils' knowledge and understanding of what is accepted in society as 'science'. The pupils reveal their personal constructs by commenting on what they observe and how they explain the phenomena they see. There is also a 'duty' for teachers to not only help children learn what is deemed essential by the state, through a National Curriculum, but also to provide these learners with a forum in which to explore their feelings and learn some biology (Tunnicliffe & Uekert, 2007). The science to be taught is set out in the English National Curriculum (DFE, 2013) and the place for teaching is usually the classroom.

Children come to their biology education experience with existing mental models about phenomena, which they form from their own encounters in their formal studies in school, on a field trip or playing outside. These models may be viewed as representations of an object or an event. The process of forming and constructing models is a mental activity of an individual or group (Duit & Glynn, 1996). The mental model is the person's personal knowledge of the phenomenon – in the case of this article, a specific animal species – and will have similarities to and differences from the scientifically accepted knowledge, which, in this instance, is about such factors as the taxonomic position of the animal, its significant morphological features, and so on.

Basic human anatomy and physiology are topics that are always studied in primary schools, but other living organisms should be an integral part of the primary classroom, not only for the science that can be learnt from them, but also for affective reasons. Existing work suggests that, whilst observations that are carried out for learning the facts of science are important, the personal aspects of the interpretation of observations are a key part of the experience for the pupils (Tunnicliffe & Reiss, 1997). The benefits of keeping animals in classrooms have long been recognised. Examining live organisms for themselves motivates pupils and renders teaching more effective, as well as engendering concern for the organisms, (Cassidy & Tranter, 1996), a concern that can be developed for other species as well as environmental issues.

Previously reported work carried out in zoos and a natural history museum reveals that pupils of primary age look at the specimens on display and notice salient features of anatomy, such as size, colour, legs and tails, and those behaviours that occur in front of them (Tunnicliffe, 1996a, 1996b; Patrick & Tunnicliffe, 2011). These studies showed that early childhood primary-aged children notice animals in their everyday lives. Children of this age also provide animals with an identity, which reflects an everyday system for naming. Scientific names are hardly ever used unless, as in the case of dinosaurs, there is no everyday equivalent. The official common names (such as flour beetle in this instance, rather than the everyday name, mealworm) are hardly ever heard (Tunnicliffe, 1995).

Relatively little is known both about the responses of pupils of under eleven years of age when observing live invertebrate animals and whether science inquiry skills (Turner, 2012) could be met through such studies.

Why mealworms?

Certain invertebrate animals, such as mealworms, are a judicious choice to use with primary children. These animals are easy to look after and have less demanding requirements than many other specimens, invertebrates or vertebrates. Animals used in primary classrooms need to be easily obtainable, easy to care for, require cheap, safe and appropriate housing, have manageable temperature and food requirements, proffer minimal safety risks and health hazards and yet be active so that they engage the attention of pupils. Moreover, species used with primary children should have the potential to be the focus of investigations, which the pupils can design and carry out, as well as being part of discovery learning where the pupils carry out investigations prescribed by someone else. Animals most often studied in primary classrooms, for instance woodlice and snails, more often than not are returned to their original habitat after completion of the investigation, so removing the possibility of observations and investigations over a period of time.

In addition, mealworms are frequently referred to as merely 'worms'. Indeed, a 2 year-old in a stay-and-play science session in a North London nursery last summer immediately named the mealworms on an observation table as 'worms'. This is an excellent example of the need for human beings to identify that which they see to the nearest category that they recognise and in which they see similarities.

Mealworms and the science curriculum

I wanted to explore the educational potential in terms of spontaneous interest from pupils in an organism that can live permanently within a classroom and require minimal maintenance, but which can also provide excellent opportunities for pupils to learn relevant science curriculum concepts. I also wanted to identify the main topics of comments made by the children when looking at these organisms and whether this content changed with older children. Hence two age groups were chosen.

The English National Curriculum is the minimum entitlement for a child's education in England. Work with mealworms provides opportunities to contribute to the aims of the curriculum for 'all pupils', which are:

- to develop scientific knowledge, in this case biological, to develop *'an understanding of the nature, processes and methods of science, such are achieved through different types of science enquiries that help them to answer scientific questions about the world around them'*;
- to become equipped to be able to understand uses and implications of science;
- to be drawn together and the foundations laid in this work for further development up the school (DfE, 2013).

English state schools are very focused on assessment, and listening in a structured way to what pupils say can reveal what they notice and how they interpret these individual or group observations, as well as what questions these raise in their minds and what further investigations or knowledge they need and can be encouraged to find out.

I considered that work with mealworms could provide opportunities for the learning of science, facts, process skills and general issues, as well as for observations and interpretations from the children, an important inquiry skill (Turner, 2012). Listening to children's comments, as well as indicating what questions the observations raise in their minds, can reveal what further investigations or knowledge they want and need for meeting curricular requirements, as well as suggesting accessible targets that they can be encouraged to explore and find out for themselves.

Discussion about mealworm larvae and adult mealworms can help children clarify the classification of those animals that undergo a complete metamorphosis and can establish that both larvae and beetle are the same kind of animal, an insect and, at the same time, also called an animal, hence they are a 'mealworm' (*Tenbrio*) – beetle-insect-animal. This is a difficult concept for some children to master (Allen, 2010). Using mealworms, which are familiar to some children, with the expectation that, through looking at them, the children may give them an everyday name, was of interest to me.

Some animals that undergo complete metamorphosis look distinctly different in their young stage, their change stage (when their internal anatomy and external features are rearranged) and in the adult form. This phenomenon causes problems for learners in identifying these physically different-looking beings as the same type of animal but at different stages in its life. For example, a caterpillar does not resemble its adult form, the butterfly, nor does it look like the chrysalis (when it undergoes its change from young to adult). Children have to learn to recognise all three forms of the same animal as different. Each stage of its life history looks very different to the next stage; in the case of mealworms, the larva is long and segmented with three pairs of legs behind its head; the pupal or change stage is of a different shape and colour; whilst the adult, the imago or beetle, is brown and in a different form, with wings and wing case. Such an instance of an animal that differs in appearance at different stages of its life cycle, but which is the same animal, was referred to by Bruner, Goodnow and Austin (1956: 2) as 'identity class', whilst recognising that a different kind of similar-looking larval form, for example a caterpillar and the mealworm larva, are members of an 'equivalence class'.

The research animals

The animals used in this study were specimens of *Tenbrio molltar*, readily obtainable in their larval form from pet shops, where they are sold as food for other animals, usually reptiles. These animals are very easy to keep in classrooms and, as far as is known, they cause no allergies in children. They can be left with sufficient food and a moisture source (a piece of cut potato for example) over weekends and holidays and so the whole life cycle of an animal with complete metamorphosis can be observed. These animals are far more satisfactory for young children to study than dealing with caterpillars purchased by the school, with these frequently dying following the emergence of the imago.

A mealworm has a different form in each of the three stages of its life cycle. At the young or larval stage, it is a long segmented animal with 3 pairs of legs at the front end and a support leg on the last segment of the body. The larva, when it first hatches, is 1cm long. As it grows, it sheds all its body covering, its skin, which is a *chitin exoskeleton.* At the final larval stage, the animal is about 3cms in length and moves relatively quickly. The change, or pupal, stage (when it is undergoing complete metamorphosis) reveals an animal that is white and curved and largely quiescent, and the adult, or imago, takes the form of a light red-brown beetle, about 1cm in length, when it first emerges, whose colour darkens as it ages. Full details about mealworms can be found in CLEAPSS (2005).

The research questions

My research questions were:

- What do primary school children say when they are asked to observe mealworms?
- Do these comments vary as children grow older?

To answer these questions, I carried out a project in a voluntary-aided Church of England school in a town in south east England with a relatively low unemployment rate. The Headteacher obtained all necessary permissions and the anonymity of the children participating was observed.

I asked pupils from Years 2 (age 7) and 5 (age 10), in small mixed gender and ability groups, to observe and record a small living invertebrate, *Tenbrio molitar,* with distinctly different physical stages in its life history. Thus, the purpose of the study reported in this article was to find out what observations pupils of primary age made when asked to observe and record a small living invertebrate in the classroom, with the aim of building up information about pupils' responses to differing organisms in order to help teachers select the species most appropriate for helping children to learn particular concepts such as classification, structure of taxonomic groups, behaviour and responses, and life cycles.

Methodology

Organising mealworm observations

Each group of pupils was provided with a see-though plastic vegetable container measuring 15 x 9 x 8cm with bran at the bottom, which contained several specimens of the larvae, pupae and imago, so that they could easily observe the three stages of the life cycle with the naked eye. Hand lenses (x10), plastic petri dishes and see-through straws were provided as tools to enhance observations.

Firstly, the pupils were asked to observe and then, secondly, say what they noticed about the animals. I recorded their conversations and analysed the content in the same way that I had done in previous studies (Tunnicliffe, 1996). The majority of comments were about the animals. Other comments were about the activity, and the items that the children were using. The animal-focused category was sub-categorised into six subordinate groups to which comments were allocated:

- Interpretative comments, which included knowledge source comments such as questions and references to a source of the information proffered;
- Affective comments, which included emotive responses such as 'Ah!' or 'Ugh';
- Environmental comments, which referred to the natural habitat;
- Comments about the animals' structure;
- Comments about the animals' behaviour; and
- Comments about the animals' names.

The comments about the anatomy and behaviour of the mealworms were grouped into four main categories, of which three were anatomical:

- those concerned with the front end of the animal;
- those associated with the dimensions of the animals;
- those features that were unfamiliar to the observers, which included structures such as antennae, and disrupters (the legs of an animal that disrupt the outline of the animal's shape).

Comments on behaviours included the position of the animal movement, feeding and anything else, such as apparent mating, which caught the attention of the pupils.

The numbers in each category for each group were added up. This was based on methodology already having been developed and tried (Tunnicliffe, 1996a, b).

Results

All the data from the recording of spontaneous dialogue were transcribed, and were counted and, thus, an overview of the frequency of mention of certain categories that emerged from the 'read/re-read' technique, but which were the same as those previously found in the researcher's work, emerged. Table 1 shows the categories of conversation in which the main topics were mentioned by the children:

Table 1. Number of conversations of all pupils in which the main topics are mentioned at least once in a conversational unit (n = 308).

Topic	mealworms no. (n=308)	%
Management /social	240	78
Exhibit access	89	29
Other items	169	55
Body parts	223	72
Behaviour	213	69
Names	188	61
Affective attitudes	155	50
Emotive attitudes	148	48
Interpretive	302	98
Knowledge source	280	91
Real/dead	57	19
Environment	15	5

Firstly, the pupils talked about the animals. Secondly, half the conversations also referred to something else associated with the animals, such as a tool to enhance observations, as the following conversation between Year 2 pupils shows:

Boy 1: *My tube's [the see-through straw] gone. Where's my tube? Where did you get that tube from?*
Boy 2: *Luke, Luke!*
Boy 1: *My tube's gone, oh, there it is!*

A more detailed analysis of the comments (see Table 2) shows that the majority of the comments were about the dimensions of the animals, their shape, size and colour, and stages or roles in their life histories. Conversational unit 4 considers life histories and the body, as well as numbers of legs:

Conversational unit 4 (Year 2):

Boy: *It's a mummy one!*
Teacher: *It's a mummy one, is it? How can you tell that?*
Boy: *'Cos Daddy ones have more legs at the back than at the front and mummies have babies.*

Table 2. The number of times that body parts or behaviours were mentioned at least once in a conversation.

Body parts & behaviour mentioned		
Topic	no. n=308	%
Body parts	273	72
front end	38	12
dimensions	169	55
unfamiliar	66	21
disrupters	84	27
Behaviour	213	69
position	99	32
movement	151	49
food related	39	13
attractors	83	27
Names	188	61
identity	187	61
Affective attitudes	155	50
Emotive attitudes	148	48
Interpretive	302	98
Knowledge source	280	91
Real/dead	57	19
Environment	15	5

However, few pupils remarked about the head end and legs.

Conversational unit 5 (Year 2):

Boy 1: I'm going to draw it!
Boy 2: How many legs has it got?
Boy 1: Four.

Unfamiliar parts, such as antennae or wings, were mentioned in about a quarter of instances.

Conversational unit 6 (Year 5):

Girl: *Ugh!*
Girl: *That one's moving now.*
Boy: *Oh, I know! They have a thing on their heads and little things that they eat with.*
Boy: *Like spiders, like tarantulas, they go [mimes movement of antennae].*

Conversational unit 7 (Year 5):

Girl: *This one looks as if it has wings [pupa].*
Teacher: *Yes, well, if it is going to change into a beetle, it will need wings.*
Girl: *Yes, they have wings on their back.*

Similarly, behaviours that children deemed to be worthy of comment included movement in half of the exchanges heard. The position of the organisms was relatively unimportant because the animals were easily located. Behaviours that attracted comments, particularly fighting or mating, were mentioned in over a quarter of exchanges. Behaviours provide many examples of pupils interpreting what they see from their own experiences using metaphors. A Year 2 boy commented that *'They are both cuddling'* as he watched two larvae entwined as they moved across each other. Comments about feeding were relatively infrequent and comments were associated with movement.

Conversational unit 8 (Year 5):

Girl: *That one's digging.*
Teacher: *Why do you think they are doing that?*
Girl 1: *For food, why do they need food? They are living in it.*
Girl 2: *Oh, yeah.*
Boy: *I wish I could live in my food!*
Girl 1: *Do they, you know, mate?*
Girl 2: *I just found a maggot underneath.*

Names were used in just under two thirds of conversations. Names give an identity to the organisms and reflect the previous experience of the pupils. Hence, one boy wondered if the larvae were baby snakes. In Conversation unit 9, Year 5 girls (10 year-olds) talked about shells, a molluscan feature, but frequently used to refer to any hard covering on an animal by both children and adults.

Conversational unit 9 (Year 5):

Girl 1: *Maggots, huh, has...*
Boy: *Maggots! What kind of maggots?*
Girl 2: *And there's one here that's got cracked shell but it's still alive [beetle with half an elytra].*
Girl 3: *Oh yeah, oh, you can blow though them [using the straws].*

Girl 2: *Yes, used to blow through them.*
Girl 1: *Beetles only have black backs.*
Girl 2: *Yes.*
Girl 1: *They are insects because insects have 6 legs and that's what they [are] called.*
Girl 2: *There are the maggots like fishing ones. Actually, they are not maggots, it's what they call centipedes.*
Boy: *No, they don't use big ones, like those.*
Girl 2: *Yes they do.*
Girl 1: *They move with muscles.*
Girl 3: *Yeah, they move with muscles. Their legs... one goes up to the front and one goes up in the middle and then the back ones come. They have come out of their shell, that's what it looks like!*

A number of pupils identified the larvae as maggots (unit 12), but correctly categorised the imagos as beetles (unit 9), yet were able to identify a stage in a life history in which form changed between stages (unit 13). Pupils were apparently using an everyday way of categorising the animals (Tunnicliffe, 1995). However, the pupils had two issues to contend with in naming mealworms; firstly the type of animals and secondly the stage, recognising that the different physical stages they observed were in fact in members of the same species but at different stages in the life cycle, identifying class as well as the equivalence class (Bruner, Goodnow & Austin 1956: 2). The girls in Conversational unit 9 recognised that the organism identified as a beetle is also a member of the insect group, hence permitting the organism to have two names at the same time, being both beetle and insect, a phenomenon that pupils under seven find difficult to grasp (Markham, 1989). The larvae, however, were identified as maggots – something different in biological terms but an everyday category used by non-biologists to represent small-segmented organisms.

The movement of the mealworms attracted comment and they were described with all their salient features:

Conversational unit 10 (Year 2):
Boy: *Ugh, look at that white one, look at that moving big thing there and they turn into that white thing and then they turn into a beetle.*

Lack of movement suggests that the animal is dead. The following conversational unit also shows how pupils matched the unfamiliar and unknown (the mealworm larvae) with something similar that they had encountered (the leather jacket larva) and provided a name and identity for the animals:

Conversational unit 11 (Year 5):
Boy: *Strange, look at that moving thing there, look at that maggot.*
Girl: *Look at that one, that's all died.*
Boy: *I've seen those before, my dad found one in the ground [a leather jacket, perhaps?].*

Anatomical features are observable, but there is a tendency to notice the salient features, such as size and colour, unless encouraged to look at other features important to science learning, such as number of legs.

Conversational unit 12 (Year 2):
Teacher: *Do you know what they are and how many legs they have? What else can you see?*
Boy 1: *They are maggots.*
Boy 2: *Maggots, what's that?*
Girl: *The big fat white ones and black ones. Look, Ross, one of those they have black, look, they go into black and turn into a beetle.*
Boy: *Ugh, we've got a black one.*
Teacher: *They turn into beetles, that's right.*

The stage in a life cycle is identified based on expectations from other learning experiences and on size, a criterion often used by young children (Loft, 1971)

Conversational unit 13 (Year 2):
Boy: *I've seen a mummy one.*
Teacher: *You've seen a mummy one? How do you know it's a mummy one? You can't just say 'I've seen a Mummy one', how do you know?' How do you know it's a mummy one, you tell me?*
Boy: *Hm. Mummy ones are these ones [pupae], daddy ones can be longer.*
Teacher: *So the mummy ones are the little ones and the daddy ones are bigger?*
Boy: *Yes.*

Teacher: *Do you know, I don't think anyone knows. The mealworm larvae don't have babies, they have to grow up first.*
Boy: *Maggots.*

In some cases, previous learning is applied. The girl in the following exchange remembered learning about caterpillars and was able to apply the knowledge, largely unnoticed by the rest of her group:

Conversational unit 13 (Year 5):

Girl 1: *Ugh!*
Boy: *Dead, dead,*
Girl 1: *Some are dead.*
Girl 2: *That's turned into a chrysalis.*
Boy 1: *That one's squashed.*
Both: *Ugh!*
Boy: *Have you seen anything like this before?*
Girl 2: *The chrysalis, it's got buried there.*
Boy: *They can flick over there.*
Girl 1: *It's dead.*
Boy: *That maggot, that will eat that.*

The above conversation shows the frequently-used criterion for being alive: movement.

Some pupils began to categorise the animals spontaneously; for instance, in Conversation unit 14, which provided an opportunity to develop categorisation or grouping in biological taxonomy terms, rather than everyday taxonomies, which are persistently referred to elsewhere in the conversational exchanges reported in this article: minibeasts, maggots and worms.

Conversational unit 14 (Year 5):

Boy: *They're kinds of maggots, but they are not, they are worms.*
Teacher: *No, they are not worms, are they, because do worms have legs?*
Boy: *No, they are part of things.*
Teacher: *Come on, what sort of animals are they then? These are all called mealworms, but what group of animals do they belong to?*
Girl: *Worms?*
Teacher: *No.*
Girl: *Beetles.*
Teacher: *Yes, and what group do beetles belong to?*
Girl: *Larvae.*
Teacher: *No, being a larva is part of being a beetle. If you had to group the animals?*
Girl: *Minibeasts.*

The data show that younger pupils are more interested in the tools they can use (p <.005) than older ones, although pupils at both ages were interested in and commented on these.

Conversational unit from older pupils focused on tools including a scientific observation:

Boy: *Can I use a magnifying glass?*
Girl: *It is an insect because they have got 6 legs.*
Boy: *Can I use a magnifying glass?*

Age-related differences in the emphasis of conversations

Although both age groups named the animals in similar numbers, the older pupils referred to behaviour ($p<0.01$) and structure ($p<0.025$) more than the younger ones. Conversely, younger pupils made more interpretative comments ($p<0.025$) and significantly fewer ($p<0.01$) affective attitudes, which included emotive ones ($p< 0.025$). Young pupils did not comment as much on a number of categories compared to the older children (see Tables 3 and 4).

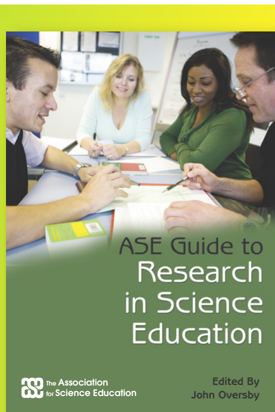

Table 3. Content of conversation units about mealworms shown according to age groups.

	age group 2 n=167		age group 1 n=141		chi 2 1df	Probability	Phi2
Category	No.	%	No.	%			
Management /social	131	78	109	77	0.06		
Access	50	30	39	28	0.19		
Other items	98	57	119	84	24.29	p<0.005	0.02
Body parts	130	78	93	66	5.41	p<0.025	0.02
Behaviour	126	76	87	62	6.77	p<0.01	0.02
Names	114	68	73	67	8.72	p<0.005	0.03
Affective attitudes	96	57	59	42	7.48	p<0.01	0.02
Emotive attitudes	91	55	57	40	6.06	p<0.025	0.02
Interpretive	161	96	141	100	5.12	p<0.025	0.02
Knowledge source	155	93	125	87	1.60		
Real/dead	37	22	20	14	3.22		
Environment	13	8	2	1	N/A		0.02

Younger pupils were intrigued by the magnifying glasses and other pieces of equipment made available significantly more than the older pupils, yet they commented significantly less about body parts and behaviour (although such comments still occur in two thirds of conversational units). The younger pupils also made affective comments significantly fewer times. They made fewer comments about the environment although, overall, very few such comments were generated.

Discussion

Developing science skills and knowledge and understanding

Naming something is usually the first narrative action carried out by children and, indeed adults, once the animal has been located. By providing an identity, naming is an important part of the observational process and children then allocate the animals to a category, which functions as a name and also an overarching, or superordinate, category group name.

Table 4. Comments about body parts, behaviour and names according to age groups.

	age group 2 n=167		age group 1 n=141		chi 2 1df	Probability	Phi2
Category	No.	%	No.	%			
Body parts	130	78	93	66	5.41	p<0.025	0.02
front end	27	16	11	8	4.95	p<0.05	0.02
dimensions	91	55	78	55	0.02		
unfamiliar	45	27	21	15	6.60	p<0.025	0.02
disrupters	55	33	29	21	5.90	p<0.025	0.02
Behaviour	126	76	73	67	8.72	p<0.005	0.03
position	65	39	34	24	7.69	p<0.01	0.03
movement	90	54	61	43	3.46		
food-related	28	17	11	8	5.57	p<0.025	0.02
attractors	49	29	34	24	1.06		
Names	114	68	73	52	8.72	p<0.005	0.03
identity	112	67	75	54	5.57	p<0.025	0.02
category	103	62	73	52	3.06		
compare	41	25	22	16	3.76		
mistake	35	21	16	11	5.11	p<0.025	0.02

This evident preoccupation, or instinctive response, of the pupils with finding or allocating a name or label for the animals is unsurprising, because categorising and then naming that which is around us is a basic human need. In the naming process, pupils are establishing the discernible features through their own observations. They are also beginning to provide not everyday names but science categories. The learner has to be able to recognise the constituent parts if they are to identify specific attributes. In Conversational unit 7, for example, a boy noticed the jaws of the mealworm in action and another boy likened this to the *chelicerae* of a spider, mentioning a tarantula, presumably based on a first-hand or secondary experience. However, before a concept can be categorised, that concept has to be acquired. These children, in some instances, considered the animals to be worms or maggots, whilst in Conversational unit 8, one girl displayed knowledge of a number of arthropod groups.

Pupils were seeking to provide an identity and categorise the animals and some pupils showed evidence of having learnt criterial attributes. Similarly, when a Year 2 boy remarked, '*They are kind of maggots, but they are not, they are worms*', he was beginning to recognise variation in patterns observed.

Work in the primary classroom provides opportunities for learning the constituent parts of the organisms as well as their main behaviours. Pupils observed different stages of the animal within its life cycle and learned to recognise *identity class members* – the larvae, pupae and beetle are all members of the same species. They also learned a number of *equivalence* categories for different types of invertebrate species; centipedes and maggots were mentioned as separate species and not identity class members, which the specimens observed were (see Bruner *et al*, 1956). The primary science name for an artificial category of invertebrates, minibeasts, which came into use in many primary schools in the 1970s, was seldom used by the pupils.

The first-hand observations of mealworms in all stages of their life cycle provide ample and relevant opportunities for pupils to observe the life processes in action, in particular movements and reproduction. The easily observable stages in the

life cycle provide relevant opportunities for introducing or consolidating the concept of complete metamorphosis, linking it with the traditionally-taught tadpole-frog and caterpillar-chrysalis-butterfly cycles, which are often the only examples studied by pupils during their primary education. Some pupils spontaneously applied their knowledge of life histories and different stages to the way they interpreted their observations. Such encounters with the different stages in a life history are important concrete experiences, which assist the learner in moving towards a complete understanding. The mealworm encounter provides a necessary link in learning the universality of life cycles.

Pupils observing mealworms witnessed variation between individual animals, noticing that some are bigger than others, colours differ and appearance varies between life cycle stages. Using mealworms in classrooms is a more satisfactory means of illustrating the concept of complete metamorphosis. Unless there is a pond in the school grounds, the collection of frogspawn from the wild is now illegal. Buying caterpillars, such as those of the Moon Moth, is expensive and very often they or the imago die. Mealworms live happily in their container and reproduce, so can always be viewed. Pupils could, if this study is replicated, be given a key to identify the animal, or they could use the organisms here as part of constructing a key of other invertebrates readily available in primary classrooms and their environs, such as earthworms, woodlice, slugs, snails and spiders.

Once the organisms had been identified and categorised, pupils made observations that could be developed into systematic investigations. The pupils used first-hand experiences as well as secondary ones obtained from teachers and peers. Subsequently, the pupils used drawings provided by the teachers and books to find out more for themselves about the animals. Observations were made based on what was seen. These observations could then be used in drawing and writing about the animals. Pupils used scientific units of measurements. Such opportunities for measuring and using units could be developed further.

Older pupils showed a greater interest in the front end of the animal – the face and eyes – and the unfamiliar and disrupters – legs, antennae and wings. Surprisingly, because younger pupils usually comment more about such aspects (Tverksy, 1984), comments about dimension, size and colour, for instance, were similar in both age groups. The behaviours about which older pupils commented significantly more included the position of the animals and food-related behaviours. Older pupils named the organisms significantly more by providing an identity. However, they also made markedly more mistakes in their naming, often calling the larvae 'maggots'.

Linked with providing an identity for the animals and observing their anatomy and behaviour are opportunities for developing and using appropriate vocabulary for the topic, science process, equipment and measurements. Furthermore, studying mealworms provides an opportunity for Health and Safety issues to be addressed, for instance, washing hands after handling the animals and also showing care and consideration for other living things.

Ideas for investigations emerged from the pupils as a result of their observations. A greater emphasis by the teacher on this, as well as encouraging further opportunities for raising questions would increase the experience of pupils in this area of the curriculum. The pupils were using deductive reasoning based on their own understanding, as shown in the conversation about the rationale behind one life cycle stage representing the mother and another the father.

First-hand observations assist pupils in learning the 'eat and be eaten' cycle of life, or energy flowing in the environment. Pupils can trace the food chain of the mealworms back to plants (in the bran or, more obviously when lettuce leaves or potato pieces are added to the containers) and this can link in with investigative science as well as environment studies.

Mealworms live in a convenient habitat for study in the classroom. Their adaptation to this dry, enclosed and dark habitat can be identified, discussed and contrasted with the environment of other readily available animals, such as the wood louse, pigeon and snail. Meaningful investigations about conditions in the habitat can be designed and effected. Moisture, for instance, may be added to the habitat in the form of pieces of potato and the larvae will develop more quickly. Shining a torch through the base of a clear container can illustrate the negative phototropic behaviour of the animals.

While pupils explored the animals provided with the teacher responding to their observations, on occasion they were given 'secondary' information to develop the observations being made. Thus, the work was of an exploratory nature, within the curriculum focus, and so developed according to the relevant parts of the English National Curriculum. However, the work led to elicitation of the pupils' ideas and formed a meaningful and relevant opportunity for the teachers to encourage them to test ideas against evidence. The task set, to draw the animal and write down a few observations, is very much part of the exploratory phase of learning.

There was a distinct difference in emphasis in the observations made by the younger compared to the older pupils, a different result from studies of observations made at animal exhibits, zoos or museums by children of similar ages (Tunnicliffe, 1995). There may be a number of reasons for this. Pupils were in familiar physical territory and had not had the many and varied affective experiences that form part of the 'field trip' or school outing.

All the pupils could see the animals easily and were able to physically interact with the specimens. Moreover, the task that the pupils were given with the mealworms was simple but clear; often a task set during visits to animal exhibits can be unclear or nebulous.

Any interactions with tools or equipment, after a few practices with hand lenses, were focused on the animals and not on adjacent phenomena, as can be the case with many museum interactive experiences. Such an observation reinforces the need for a spiral curriculum, introducing the topic at different stages in a child's learning journey so that, each time the concept is met as the child matures, they construct further understanding.

Implications

Consideration of the data, quantitative (numbers) and qualitative (words) in the conversations, shows three main things:

- Insight into what the pupils do observe when looking at a living animal. Observations include how pupils name the organisms, what anatomical and behavioural features they notice, and that such observations change in the emphasis of the content as pupils get older;
- Pupils respond to the living animals at all stages of the mealworm life history; and
- The use of mealworms in class provides opportunities to give pupils first-hand experiences, which in turn enable them to fulfil the requirements of the curriculum: science, maths, design and technology, information and communication technology and language.

The use of appropriate live animals in primary classrooms should be encouraged. The observations and investigations focused upon them not only enable teachers to meet the requirements of the curriculum, but also introduce pupils to the first-hand observations of living things.

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Helping children to express their ideas and move towards justifying them with evidence: A developmental perspective

Linda McGuigan

Introduction

The development of children's confidence to express their own ideas and to listen to the ideas of others is at the heart of early years practice. Everyday interactions between children and their teachers aim to support children's developing confidence, social, emotional and language skills. In the course of our research into emergent science in early years settings, we have gained an understanding into how some of the early interactions valued for general development help to develop the foundational skills essential for what will later be understood as argumentation in science. In this article, we describe what we mean by argumentation in science. To do so, we draw on some of our research to provide insights into some practical strategies adopted by early childhood practitioners to encourage the expression of ideas and reasoning that are foundational for later science learning.

Understanding argumentation

Argumentation is concerned with a particular kind of thinking that we know as 'reasoning'. It is a way of expressing reasons for ideas and actions and it is acknowledged that exchanges of this kind influence the development of new ideas and new understandings (Mercier, 2011; Duschl & Jimenez-Alexandre, 2012). Argumentation requires children to express ideas clearly, give reasons for those ideas and to listen and respond to the ideas and reasons offered by others. The expression and exchange of ideas supported with justifications are central to science and an important aspect of working scientifically in primary science.

There is accumulating evidence of early years children displaying the capability to express ideas and to reason (Piekney & Maehler, 2013). Much of this research has been gathered during individual interviews in which children have been withdrawn from settings. Our approach differs by starting with the holistic practices of the early years to explore the possibilities for practitioners and other supporting adults, encouraging the expression of ideas and scientific reasoning. We have reported (Russell & McGuigan, 2016a) how the everyday interactions can be shaped to offer developmentally appropriate opportunities for children to build on and refine their understandings. Such reasoning skills are foundational for argumentation in science.

Encouraging the confident expression of ideas

The clear expression of ideas requires children to bring together their developing social, emotional and linguistic skills. Patience and careful listening skills on the part of adults are required to make sense of some of the ideas and information that may be expressed. Many of the direct experiences and opportunities for handling and observing real objects familiar in early years settings provide opportunities for supporting the expression of understandings. Our view is that children have ideas and that, while language is important, ideas can also be expressed in 3-D models, drawings, actions, dance, and mathematical tools such as counting, charts, etc. The techniques for encouraging the expression of ideas are limited only by our imagination and creativity as educators. We have argued elsewhere (Russell & McGuigan, 2016b) that each of these models used singly and in combination helps children to show different aspects of their understanding. For example, a 3-D model reveals ideas about the whole of an object. The relative position and size of different features can be made explicit. Children's early years experiences may often focus on observing animals, considering what they look like, what they need to live and how they might be cared for. Figure 1 shows a child (age 36 months) making a 'home' for a snail she has found in the pre-school garden. She explains her reasons to her teacher for each of the materials she wants to include: *'Plant pots to keep the rain and wind out'*, *'Grass for food'*, *'A bottle top filled with water because the snail will be thirsty and like a drink'.* The holes in the plant pot at the top of the model allow her to look inside to *'see the snail is happy'.* She reveals awareness that the snail will need food and water to live. Using words like 'thirsty' and 'happy' shows how she draws on her own experiences to explain the snail's needs.

Figure 1. Revealing ideas about what a snail needs to live.

Children may not be aware that they have ideas and some children may have become used to saying *'I don't know'*. Supporting adults should not be put off by this. They need to hold expectations that children have ideas and gently encourage their expression. As children develop confidence and actively participate in conversations, they will begin to recognise that they have their own ideas and that others have ideas that may differ from their own**.**

For instance, children in a nursery setting (age 3 years) observing changes in the daffodil bulbs they had planted made sequenced drawings to show some of the changes in the bulbs. The conversation between children and the supporting adult as they completed their drawings helped the children to become aware of each other's ideas:

Teacher: *'Just have a think. Let's see if we can come and make a picture. A picture that tells the story of what happened. I wondered if you could put the beautiful flowers at the end and you could go back to tell the story of what happened?'*

Harry: *'I'm going to do the grass now.' [The teacher thinks about Harry's idea and invites the other children to describe their ideas as part of the conversation.]*

Teacher: *'Mmmm...Was grass part of the story of what happened to the bulbs?'*

Cameron: *'Grass doesn't make it grow. Soil makes it grow. Water makes it grow. Flowers can grow. And water... If they are dying they put lots of water on.'*

Teacher: *'Cameron, I think you explained that very well.'*

Teacher: *'Harry, were you listening to Cameron? He thinks soil helps them grow. What else did you say, Cameron?'*

Cameron: *'Water.'*

Teacher: *'Water helps them grow and Chloe said that as well. Have you seen Chloe's picture?'*

The adult's approach is initially open-ended, aiming to encourage the expression of a range of ideas and to arouse children's awareness of their own ideas and those of other children. Her conversational style puts children at ease, avoids them feeling threatened and encourages diverse contributions. By responding with interest and curiosity towards the expressed ideas, she is in turn encouraging children to think about the ideas that are being revealed. The way in which the teacher raises children's awareness of the different ideas provides them with very early opportunities to think about and compare each other's ideas.

Encouraging reasoning and participation

A step on from developing the confidence to express ideas is the capability to give reasons for ideas. Teachers asked children to give reasons for their ideas at every opportunity. Initial responses offered by some children, such as *'Because I think so'*, were gently challenged with questions such as *'Why do you think so?'*. For example, in response to a windy day and children's interests about the effects of wind on themselves and on different objects outdoors, children were encouraged to design and make devices that could help them to decide whether or not a day should be described as 'windy'. The activity required them to use their developing understanding of materials as well as awareness of moving things. The devices provided a concrete and shared focus for the group discussions, in which children were encouraged to exchange ideas and explain their reasoning. Children were asked, firstly, to listen carefully to each other; secondly, to think about whether they agreed or disagreed with the ideas – in other words, to compare the expressed idea with their own idea; and, thirdly, to give reasons for their ideas:

Teacher: *'Sam and Millie have come up with a lovely idea for a wind measurer and we are going to listen very, very carefully now and start to think about what we think of their ideas. Whether we agree with what they have decided to use, or disagree and why?'*
Rebecca: *'Sam, what are you going to use?'*
Sam: *'We are going to use paper.'*
Teacher: *'What do you think about that, Rebecca? Do you think that is a good idea?'*
Rebecca: *'I think that's a good idea.'*
Teacher: *'Why do you think that's a good idea?'*
Rebecca: *'Because paper is bendy and light. It moves when you blow it.'*
Maisie: *'What if it rains? It will get wet.'*
Millie: *'We'll put it under the branches of a tree so it doesn't get wet.'*

We can detect, within the dialogue, children's emerging capabilities to ask questions of each other, to listen to each other's responses, to give reasons and to use their knowledge of materials in their reasoning. The teacher actively encourages children to listen and to reflect on the ideas expressed. Her approach includes asking children what they think of an idea and encouraging them to explain why they hold a particular view. By asking children to decide if they agree or disagree with ideas, she is requiring them to access their own thoughts and to compare emerging ideas with their own.

A further step in developing children's science reasoning capabilities was to help children begin to distinguish between the *qualities* of reasons offered. Children (age 6 and 7 years) were invited to bring into class items they wanted to be included in their class museum. They were asked to think of reasons to justify the inclusion of their chosen item. Their teacher wanted children to develop their capabilities to give reasons and to encourage them to think critically about the reasons offered in support of each object. A variety of items were brought into school, including old coins, books, fossils and toys. A variety of reasons were offered, including, *'It's very old'*, *'It's dirty'*, *'I have had it since I was a baby'*, *'Books go in museums'*. In this context, reasoning was explicitly being used to persuade and to influence the selection of items and children readily compared the reasons offered as they reached their decisions.

Work on the appreciation of evidence to justify ideas

Reasoning that refers to evidence, going beyond opinion or assertion, is gradually required in children's science learning. Children may offer a wide variety of reasons for their ideas. They might refer to imagination or their friends' views; external authorities, such as a parent or grandparents, might be used to support an idea; or information they have read about in a book or have learned on TV or online. They may also draw on their own direct experiences and observations as sources of evidence for ideas. A group of 3- and 4 year-olds observing snails were asked what they thought snails might eat. One child suggested that *'Snails eat plums'.* At first blush, responses of this kind may be thought of as unfounded assertions but, in this instance, the supporting adult gently probed the child's idea further. In response, the child revealed that he had seen snails on his Nana's plum trees and that some of the plums had been eaten by the snails. This kind of reasoning, drawing on the evidence of first-hand observation, can be nurtured very early on in the course of children's conversations with adults. In the competing demands of an early years environment, there might be a temptation to move the conversation on to what appear to be more fruitful ideas in line with the adults' expectations. Skilful teachers in our research listened patiently to and probed children's explanations. In the context of such sensitive interactions, children showed unexpected capabilities to draw on first-hand evidence.

Nurturing the giving and receiving of feedback

Specific strategies became evident that encouraged children to give feedback in a manner that was positive and yet critically reflective. Teachers modelled responses such as *'I like Bunty's reason, but…'* as a way of signalling some positivity initially, prior to offering some more critical feedback. Children readily adopted this pattern in their own responses to their peers' explanations.

Practitioners have a role in helping children handle and respond to feedback so that it is used positively to move learning forward. These skills can be fostered in children's early experiences of peer feedback. For example, children in a nursery setting (age 3 years) showed their ideas in drawings of what was needed for seeds to grow. Their teacher asked each child in turn to comment on each other's drawing. Following the feedback from peers, the teacher turned to one of the children and, putting an arm around her, asked *'Now you've heard your friends' ideas about your picture. How do you feel about their ideas? Do you want to change your ideas or not?'.* The teacher's response is comforting and supportive, ensuring a non-threatening but nevertheless critically reflective environment in which children can practice giving and receiving feedback.

Conclusion

Developing the capability to reason and engage in science argumentation can be understood as part of a journey that begins with the early encouragement from supporting adults of the confident expression of ideas. Our starting point is a firmly-held view that every child has ideas and we seek to build a supportive and engaging environment in which the expression of ideas and reasoning is nurtured in developmentally appropriate activities. Interactions in which practitioners actively support reasoning and encourage children to think about and respond critically to the ideas expressed by others is, we suggest, foundational in building towards later science argumentation.

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Why does jelly wobble? A workshop for primary school children on the structure and properties of solids

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Abstract

There are many types of solid material, but these can be described well using the particle model. However, polymeric solids such as jelly cubes do not fit easily into this model and yet these types of materials are everywhere. We present the thoughts of children as they take part in a workshop to find out why jelly wobbles. The workshop demonstrates that children are able to investigate and debate in a highly effective way when given time to do so. The idea that some materials are made up of chains of particles is not a difficult concept for these learners and allows them to build an improved conceptual model of solid structures.

Keywords

Solids, particle model, comparing, structures, discussion, questioning

Introduction

The particle model of matter allows one to explain the difference in physical properties between solids, liquids and gases and how it is possible for one state of matter to be converted into another, e.g. melting of a solid to produce a liquid (Hadenfeldt *et al*, 2014). In its simplest form, the particle model assumes that the building block for any substance is a particle and, depending on how close those particles are to one another, will determine what physical state the substance is in, i.e. solid (close together), liquid (further apart) and gas (very far apart). There are myriad ways to demonstrate the particle model, including the use of computer simulations (Tang & Abraham, 2016), drama and physical models (e.g. Merino & Sanmarti, 2008; Papageorgiou *et al*, 2010). The particle model also allows one to explain a range of other observed phenomena; for instance, why the speed of sound through a material in solid form is higher than in liquid form, which, in turn, is higher than in gaseous form, and helps to explain heat conduction and insulation. However, stretchy solids such as rubber bands and jelly cubes are difficult to explain using the particle model. Therefore, in this study we explore how the concept of chains of molecules or particles (polymers) can be used to build a conceptual model of the structure of these soft solids. Here is an example of a topic (polymers) that is not covered in the UK until around Year 10 (14-15 years old) and yet these materials are all around us, from human-made plastic bags through to natural structures such as our eyeballs. These stretchy solids are everywhere and, as we have observed, the young learners in these studies (typically aged 4-11 years old) are able to grasp the concept of chains of particles that make up these polymers quite easily. In addition, conceptual models used at primary level (e.g. the particle model) do not work for these polymeric-type materials and so it is important as part of the ethos of working scientifically to reject inappropriate models and develop better ones (e.g. Ricketts, 2014).

The workshop

The workshop is very straightforward to set up and requires only a few easily obtainable resources. Working in pairs or singly, each child is given a paper plate with some wooden cocktail sticks (at least four), some jelly babies (at least four and a mixture of colours), a jelly cube, a sugar cube and some rubber bands (various colours, not the traditional brown type). An example of a plate of materials is shown in Figure 1. The workshop has been carried out with nearly 1000 primary school students over the period 2011-2016 in schools in England.

Initial investigation

The pupils are asked some initial questions about the materials in front of them:
Can you identify all the materials in front of you?
What do you notice about the objects?
How many different materials do you have?
Have you seen them all before? Where?
What are they used for?

Responses will vary from class to class and group to group in any year group, of course, and between different-aged children. However, even the youngest pupils are usually able to identify these materials, separate out the different types of materials and make good suggestions about their actual and potential use. Interestingly, pupils usually include the plate as a material and this shows not only good observation (e.g. Tang *et al*, 2015) but also a lack of preconceived ideas; adults often ignore the paper plate altogether.

Figure 1. The various materials used in the workshop: a paper plate, a jelly cube (here, a red one), jelly babies, a sugar cube, coloured rubber bands and cocktail sticks.

Sorting

When the pupils are asked to sort these objects into groups and be ready to explain their reasons, there are many groupings that are presented on a regular basis. Normally, we would ask them to carry out a sort two or three times, asking them to sort in a different way each time. At the end of each sort, the groups share their ideas with the whole class and we will continue to find new groupings suggested, no matter how many times they sort these materials. Indeed, as the children have more time to think, they become more imaginative and scientifically more exacting. On many occasions, totally new groupings are proposed and justified that the researchers have never observed before. Table 1 summarises some common examples of the groupings that children produce. It is interesting to observe that children go beyond ideas about colour, shape and size when given some time and will always think about some other property that can be used to distinguish between the materials; this is true of even the youngest children with whom we have worked.

Rather sophisticated scientific vocabulary emerges in such studies, and allows the class to discuss concepts (e.g. Osborne, 2010) such as 'transparent',' translucent' and what it means to be stretchy. Often the cocktail stick is put into the 'flexible' group by some and not by others – why?

For some, they believe that it is not flexible because it cannot be elongated or compressed (more good use of scientific vocabulary) along the length of the stick. However, others show that if you take both ends and flex the cocktail stick, it is very bendy and flexible and can be broken. How can it have these properties? Such ideas are progressed in the next part of the workshop, and such questions are written on the whiteboard so that they are not forgotten and are returned to later in the workshop.

Some ways of sorting cause considerable debate and require further investigation (see next section). Interestingly, some children can group all the materials together; for example, *'they are all solids'*, *'they are all made from plants in some way'*. Very interestingly, one boy noted that they can all be used as weapons and, in theory, that they are all edible. Another interesting debate emerges concerning the edibility of these materials, with many children agreeing that they can eat all the materials, although most are wary that the rubber bands may make one ill and that the cocktail stick can be dangerous because it has a sharp point. Lively discussion and debate will ensue, revealing quite a sophisticated understanding of materials. However, whatever the method of sorting, children show that they have some understanding that these properties are on a scale, and one could find a material that is stretchier (and they usually suggest a number of these, including chewed chewing gum) and materials that are less stretchy (such as a metal block). The idea that properties of materials are on a relative scale is a very important concept in science. Temperature is on a relative scale; the temperature on the Celsius scale is defined by the freezing and boiling points of water under standard conditions, with all other temperatures relative to these two defined points. Here, children can define new scales for various properties based on the materials that they have:

Can be sorted immediately	
By colour	Transparent and non-transparent
By shape	Twistable and non-twistable
By size	Stretchy and non-stretchy
By length	Edible and non-edible
By mass	Man-made/natural

Can be sorted immediately but may need further investigation to verify	
Does and doesn't dissolve in water	Edible and non-edible
Flammable and non-flammable	Reversible and irreversible (if heated)
Can be penetrated by the cocktail stick, or not	Floats on water and sinks in water
Floats on honey and sinks in honey	

All one group
All materials
All edible
All come from a plant
All solids
All can be handled safely
All can be used as weapons

Table 1. Some of the groupings used to sort the materials on the plate, including the plate, and ways to describe them as one group.

why & how? PRIMARY SCIENCE TEACHING TRUST

Further investigations prompted by sorting

Some groupings can be suggested that open up the possibility of further investigation. Materials that float or sink in water is a common example, as is the grouping of materials that will dissolve in water (cold) and those that do not. This is a great stimulus for further investigation and demonstrates the 'thinking scientifically' process: make a prediction based on known data, test out the prediction and refine the thinking based on the experiments and, where necessary, modify the working model to explain the observations. If time permits, it is possible for such investigations to carry on for some time. This then allows the children to build up a very deep understanding about the properties of the materials. The next stage is to investigate why they have those properties.

Jelly cube vs sugar cube

The workshop then moves on to ask the children to compare the sugar cube and jelly cube and to list factors that are the same and those that are different. Table 2 summarises some common suggestions by the children. Inspection of the table reveals some interesting thoughts and levels of understanding. Both materials as presented are roughly the same size and cuboid in shape. It is interesting when the children begin to think about what the two materials are made of and much debate will ensue. However, in general and maybe after some time, they will generally conclude that the sugar cube is pure sugar and the jelly cube is sugar plus some other ingredients, for example some colourant or dye, depending on the student's age and vocabulary. Some students suggest that the jelly cube is flexible like a liquid and must contain some water. It is always interesting to ask the students how they could test these ideas and they produce a wide variety of answers, which include a tasting machine that can tell you how much sugar is present, a special weighing machine to show how much sugar and water there is, or a special microscope that lets you see what is inside the materials – excellent explanations, in using ideas appropriate to the age group, of analysis techniques that include chromatography, mass spectrometry and microscopy (e.g. http://www.chemguide.co.uk/analysis/masspec/howitworks.html).

Possible structure of the sugar cube

Looking at the sugar cube, children generally state that it is hard, shiny and made of tiny crystals that have been stuck together. When we ask the children what they think the sugar cube would look like if they imagine looking inside it using a very powerful microscope, they will generally say that it looks like tiny cubes. We then ask the students to use the cocktail sticks and jelly babies to build a structure that is made of the same building block shape, and they will often make a cube shape (e.g. Figure 2), but they also make other regular shapes such as a pyramid structure as seen in Figure 3. When we then ask the students to combine all the cubes together, or all the pyramids, they begin to see how it is possible for the sugar cube (crystalline

Table 2. Suggestions of factors that are the same and those that are different between the jelly cube and the sugar cube.

Same	Different (jelly/sugar)
Edible	Squishy/hard
Number of faces	Smooth/rough
Number of sides	Colour
Solids	Smell
Cubes	Taste
Dissolves in warm water	Bouncy/ non-bouncy
You can break bits off	Contains sugar / just sugar
Size	Wobbles/ doesn't wobble
Both contain sugar	

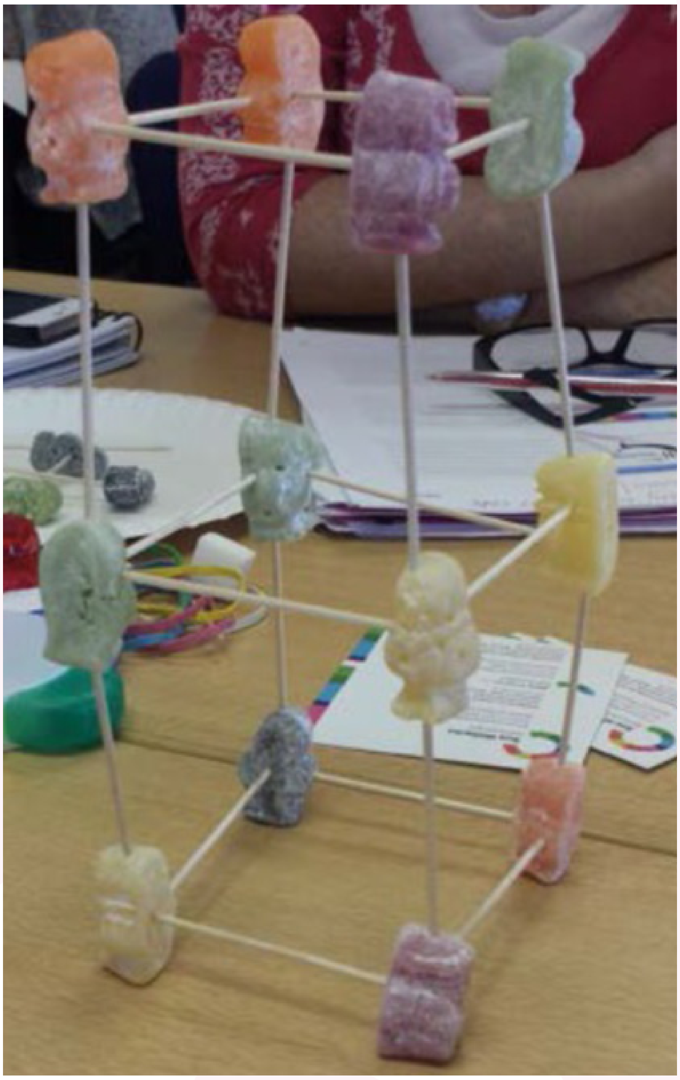


Figure 2. A cubic structure made from the cocktail sticks and jelly babies.

substance) to have a regular structure that gives it its properties of hardness, non-stretchiness, etc. Such a regular structure is part of the particle model for solids. We also discuss the number of different ways in which it is possible to build a regular structure and mention Bravais lattices, i.e. that there are 14 different known ways of arranging particles into a regular structure (e.g. Kettle & Norrby, 1993; Sein & Sein, 2015). Here, the students found out about these Bravais lattices after the workshop had finished and reported back to the class (discovered from feedback that we had from teachers and which alerted us to the *YouTube* video reported by Sein and Sein (2015)). In workshops, children can also form regular structures themselves using drama (e.g. McGregor, 2012) and can develop their understanding of the particle model through 'melting' into a liquid and 'evaporating' into a gas.

Jelly cube and the rubber bands

The final part of the workshop moves on to ask the children to compare the jelly cube and the elastic bands and to list factors that are the same and those that are different. Table 3 summarises some common suggestions by the children. There are several differences that can be observed and also several similarities. If sufficient time is given, even to quite young children, they will start to explore the rubber bands and, with some prompting, start to investigate what happens when you begin to tangle up the rubber bands. They find that they end up with a ball of rubber bands that is like the jelly cube in shape and stretchiness. At this point we suggest to the children that the reason why jelly

Figure 3. A pyramid structure made from the cocktail sticks and jelly babies.

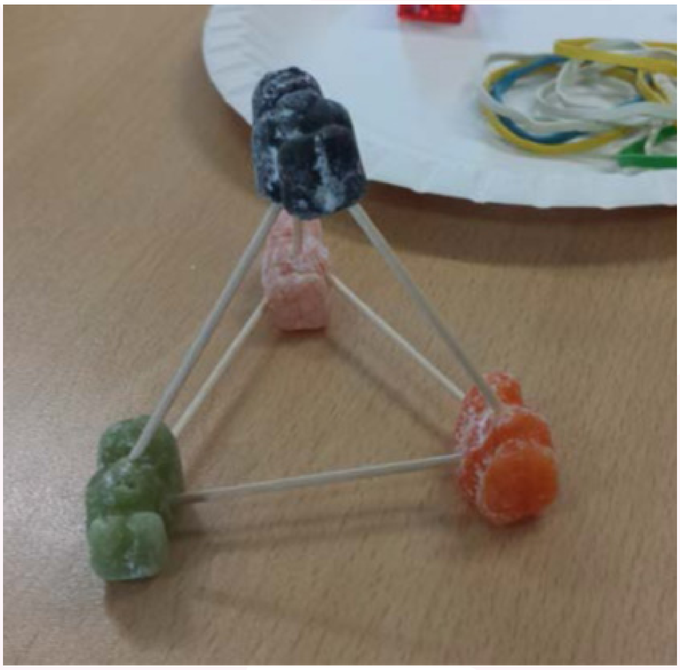
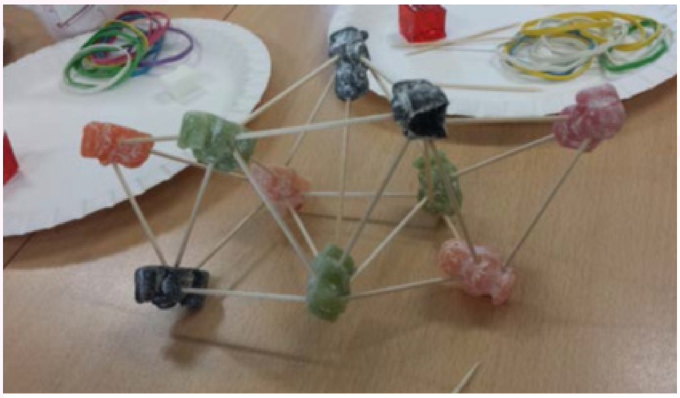


Figure 4. Several pyramid structures added together.



wobbles is because it is made up of stretchy chains of particles, like rubber bands, and that these can tangle up, although we have had many instances where they have concluded that for themselves. They can see the similarities between the two structures (jelly cube and rubber band) and, conceptually, they can understand that there is a different structure underlying the jelly cube compared with the sugar cube. It is easy to finish off the workshop by asking the children to link up into short chains of particles and asking the chains to move around and entangle themselves with other chains. This works very well with all age groups and can also be used to explain why these types of materials are also often heat insulators. If the question about the flexibility of the cocktail stick has arisen, we ask the children which structure the cocktail stick will have and have observed excellent arguments for both a regular structure and chains. However, on more than one occasion, children have concluded that the cocktail stick is made of 'lots of rigid chains all lined up', so it is hard to stretch it along the chains, but these chains can be curled up in the lateral direction.

Conclusion

The particle model is an excellent framework through which to understand regular solids and crystals and how these solids melt to become liquids, etc., and is a model that is useful throughout school science education. However, the particle model does not help to explain the properties of polymeric materials and so-called soft solids such as jelly cubes and jelly babies. Using the idea of stretchy chains, exemplified by a rubber band, it is possible to develop a model that helps primary school children to understand why these materials are different. The workshop described has demonstrated many times that children at primary school age have excellent investigative and reasoning skills, if given enough time, and that they have a wide scientific vocabulary.

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Table 3. Suggestions for factors that are the same and those that are different between the jelly cube and the rubber band.

Same	Different (jelly/rubber band)
Stretchy	Dissolves in water / doesn't dissolve
Returns to same shape	You can break a bit off the jelly and stick it back to the main cube / breaking the rubber band is permanent
Colour	Colour
Solids	Smell
Breaks when stretched too far	Shape

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Exploring children's play-based opportunities for learning science and mathematics through the gender and socio-economic lens – a new research study

Science, Technology, Engineering and Mathematics (STEM) knowledge is crucial to the advancement of any society. However, concerns have been raised over how females and those from economically challenging backgrounds are significantly under-represented in these careers (Archer & DeWitt, 2014). In addition, previous research has shown that children's aspirations are formed by the age of 14 and any initiatives to change this at this age have proven to have had little success. It has also been observed that pre-school children of different genders and socio-economic backgrounds tend to have different play choices and behaviours (e.g. Goble, Martin & Hanish, 2012; Karnik & Tudge, 2010; von Zuben, Crist & Mayberry, 1990), but there is virtually no research that examines the implications of these gender and socio-economic differences on pre-school science and mathematics learning opportunities through play. Thus, this study will attempt to fill in this research gap.

This study sets out to identify ways to address this problem at an earlier stage by extending our knowledge regarding how children acquire the foundations of scientific and mathematical understanding in the early years, through observing them during play (the main vehicle for learning). Additionally, the study also aims to examine these learning opportunities in relation to gender and socio-economic backgrounds.

Observation and interview data for the exploratory phase of the study have already been collected from five early years settings in Berkshire, UK. It is hoped that the results will form the basis of a larger project, which will focus on highlighting the importance of encouraging gender and social equality in the early years. It is anticipated that the findings of this pilot will support recommendations for policy and practice, in order to support children's mathematical and science learning in the early years.

For more information in relation to the project, or if you would like to get involved and/or participate, please contact the research team at m.kambouri@reading.ac.uk.

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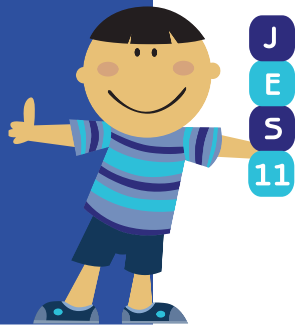

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