The Journal of Emergent Science

JES9 Summer 2015

Contents

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The Journal of Emergent Science (JES) is published by the Emergent Science Network and is supported by the Association for Science Education (ASE). From issue 10 onwards, ASE will be the publisher for this prestigious journal, with the support of the Primary Science Teaching Trust (PSTT).

From this issue onwards, this journal will be free to access for all. Our thanks go to our loyal subscribers, ASE members and sponsors for the support given to JES over the past eight issues.

Editorial

Jane Johnston

The future of JES: new horizons

I began my research career at a very early age, when I was a primary school child in Kent and was part of the Nuffield Primary Science Project. This experience fuelled my interest in science and, later, as a newly qualified but unemployed primary science specialist, my interest in research was established when I worked as a researcher prior to my first job as a classroom teacher. Even later, membership of the ASE Validation Board and Research Committee and a move into HE consolidated my two interests of early years science and educational research, and I became a Reader in Education.

However, I found it very difficult to be taken seriously at science education research conferences, as my contributions were often misunderstood, placed in sessions with papers on astrophysics or similar, and eminent professors even questioned whether young children could

The Editor (centre) as part of the Nuffield Primary Science Project in the 1960s.

actually understand scientific concepts! Twenty years after the introduction of the science National Curriculum in the UK, the situation for primary science research, let alone early years science research, was relatively unchanged, and so a group of early years professionals grouped together to become the Emergent Science Network, to raise the profile of early years science education, show how young children develop their scientific ideas, skills and attitudes and bust the myth that young children cannot grapple with complex scientific issues. Two important contributions of the Network have been the establishment of an early years strand within ESERA (the European Science Education Research Association) and the launch of the *Journal of Emergent Science (JES).*

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. It took the international definition of early years (that is, birth to 8 years of age) as its focus, thus spanning key stages of development and transitions from home to foundation stage to Key Stage 1 (age 5-7) and to Key Stage 2 (age 7-11).

JES has the following key features:

- It contains easily accessible yet rigorous support for the development of professional skills;
- it focuses on effective early years science practice and leadership;
- it considers the implications of research into emergent science practice and provision;
- it contains exemplars of good learning and development firmly based in good practice; and
- it supports analysis and evaluation of professional practice.

This is based on the important premise that good learning and teaching relies on good research (not just good scholarship) and that any educational research is pointless if it does not impact on practice or provision; that is, have a 'so what?' factor.

The first nine editions were co-ordinated by the founding Editors, Sue Dale Tunnicliffe and me (Jane Johnston), 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.

It has been interesting to look at the themes, countries involved and age ranges within the early years covered in the articles in the first eight editions. There have been 25 full articles and 15 extended abstracts from both the ESERA and the World Science conferences, from 14 countries, mainly UK and the rest of Europe, but also a few from North and South America and one each from Africa and Japan. The themes of the articles include mainly aspects of children's understandings, such as those about skeletons, misconceptions, insects, brine shrimps, magnetism, seeds/plants, the solar system, trees, drama, shadows and metamorphosis (13), and learning approaches such as photobooks, group work, mind maps, taxonomy and creativity (12). There are, however, themes of language in early editions and books in later ones, as well as a sprinkling of skills (observation, prediction, curiosity, investigation) and teacher education (2). The majority of the articles and extended abstracts focus on the 5-8 years age range, but with the 3-5 age range also being very popular.

The need for *JES* is as great in 2015 as it was in 2011; maybe even greater, as early years and primary science education has been squeezed and 'watered down' in the current over-packed curriculum. *JES* can also not only continue to raise the profile of the 3-8 age range, but also throw a light on the youngest children's scientific development. It can widen its scope from Europe to the rest of the world and share expertise, as it is only by sharing our experiences that we will become more knowledgeable and help young children to develop their emergent understandings, skills and attitudes. In addition, there is a continued need to develop understanding of educational research and, in particular, practitioner research, as distinct from scientific research. Practitioner, educational research is likely to be qualitative in nature; to be evaluative, which aims to illuminate, reflect on or clarify an issue; action research, which aims to develop practice; and observation, which aims to understand learning and teaching. The articles in *JES* can help us to understand research by looking at the methodology and methods used by the authors.

It is in this climate that we move to a new era for *JES*, one that raises the profile of emergent science higher and sees its importance further recognised by ASE, who will be taking over the publishing and copyright of *JES* from the Emergent Science Network. This edition of *JES* sees a return to 'open access', so that a wider range of early years professionals can:

- engage in emergent science issues;
- be supported by both ASE and PSTT; and
- learn from and with the early years and research expertise within a new and stronger Editorial Board, with a really international feel and with shared knowledge of early years science, educational research, or both.

This edition of *JES* contains four full articles of research carried out in France, Canada and England. Three of these articles (Bruguière, Noble & Tippett and Tunnicliffe) use drawings as a research tool, and two (Bruguière and Noble & Tippett) look at how fact and fiction can be mutually supportive in developing early years understandings. Catherine Bruguière's paper, *When is a cow not a cow? When 6-8 year-old children draw a cow described in a story by another animal*, identifies how fiction and fact can support each other in the scientific development of young children, so that *'reading of a realistic fiction picture book [and]... the use of fictional drawings offers new learning opportunities in sciences'.* Michael-Anne Noble and Christine Tippett's paper, *Dr. Blasto: Five to six year-old students' portrayal of a fictional science villain* looks at how fictional depiction can affect views of science and scientists. Linda McGuigan and Terry Russell's paper, *Using multimodal strategies to challenge early years children's essentialist beliefs* examines the teaching and learning of 'Evolution and Inheritance' on its reintroduction to the UK science curriculum after some years of absence. They identify that young children *'tend to hold essentialist views of living things that lead them to regard all individuals within a species as identical – a view at odds with biological reality'*. They stress the importance of good early years interventions to support later learning, whilst Sue Dale Tunnicliffe's paper, *What's inside an earthworm? The views of a class of English 7-year-old children*, indicates the importance of first-hand experience to support understanding.

Overall, the four articles help us to understand the complex nature of learning and teaching in the early years and pave the way to a successful transition for *JES*. I am very proud to have been involved in early years science research, from Nuffield Primary Science to emergent science.

Jane Johnston
Co-Editor of the *Journal of Emergent Science*

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* will be transferred to ASE.

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 8 years of age. The key features of the journal are that it:

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

The Editorial Board

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

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 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

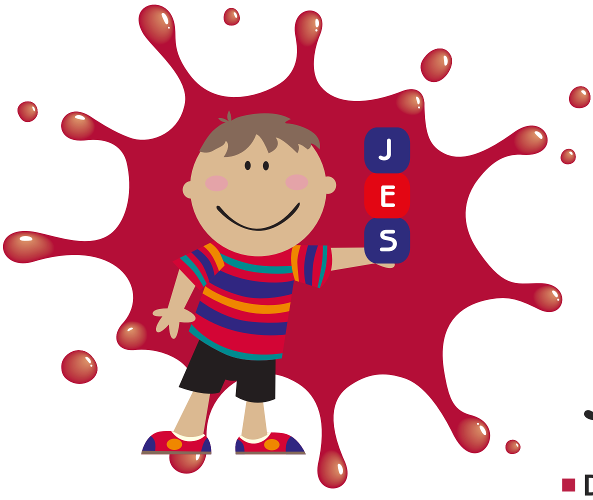
Reiss, M. & Tunnicliffe, S.D. (2002) 'An International Study of Young People's Drawings of What is Inside Themselves', *Journal of Biological Education*, **36**, (2), 58–64

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.



The Primary Science Teaching Trust & the Journal of Emergent Science

■ Dudley E. Shallcross ■ Kathy G. Schofield ■ Sophie D. Franklin

The Primary Science Teaching Trust (PSTT), formerly the AstraZeneca Science Teaching Trust, has been in existence since 1997, funded by a Trust Deed and endowed by AstraZeneca PLC. The Trust has focused on supporting excellent teaching of science at the primary school level and provided funding in the region of £6m over the period 1997-2012. In 2013 it launched a new strategy, which is based on a flower (PSTT, 2015). The flower model has three components: the centre of the flower is the PSTT's College of Outstanding Primary Science Teachers (Fellows); the petals are Collaborators with whom PSTT work on a range of timescales; and the ring between the College and Collaborators are clusters of primary schools.

PSTT sponsors the UK Primary Science Teacher of the Year Award and each winner of that award (up to 25 a year) becomes a Fellow of our virtual College. These Fellows have access to funding to support their own professional development, to support the embedding of existing best practice, to support the development of innovative practice in primary schools and to work with other stakeholders and collaborators. The Fellows also support clusters of primary schools (typically, clusters comprise between 3-10 schools) to develop best practice in primary science and to raise the confidence and subject knowledge of teachers in science within the primary school setting. Collaborators include a wide range of stakeholders and, in particular, encompass a range of academic collaborators based in Higher Education Institutes within the UK. These Collaborators provide research underpinning to the PSTT projects as well as supporting Fellows and clusters directly and indirectly. Ultimately, the goal of PSTT is to see excellent science teaching in every classroom in every school in the UK. Through the flower model, and together with its three components, we are seeking to carry out this endeavour. Figure 1 shows the progression of the flower model, from a small number of engaged clusters through to all schools in the UK being part of the PSTT cluster network and engaging in excellent teaching of science at primary level.

In order for teachers to continue on their professional journey, they need to be reflective practitioners (Schon, 1983; Brookfield, 1995) and part of that reflection involves engaging with education research, through reading research material, taking part in research and, in addition, in some cases to carry out their own research. PSTT is very keen to see teachers become research-active at all levels and the *Journal of Emergent Science* is an excellent vehicle through which to support this desire. Without losing the rigour upon which this journal was founded, we would like to support teachers to become research-active and to publish their work in *JES*. We also view the articles published in this journal to be important for teachers to access and so PSTT has taken the opportunity to partner with the Association of Science Education (ASE) to support *JES*. Therefore, from this edition, *JES* has become an open access journal and will include College Fellows on its Editorial Board. We hope that this partnership will encourage teachers to be research-active and that they will benefit greatly from this excellent journal.

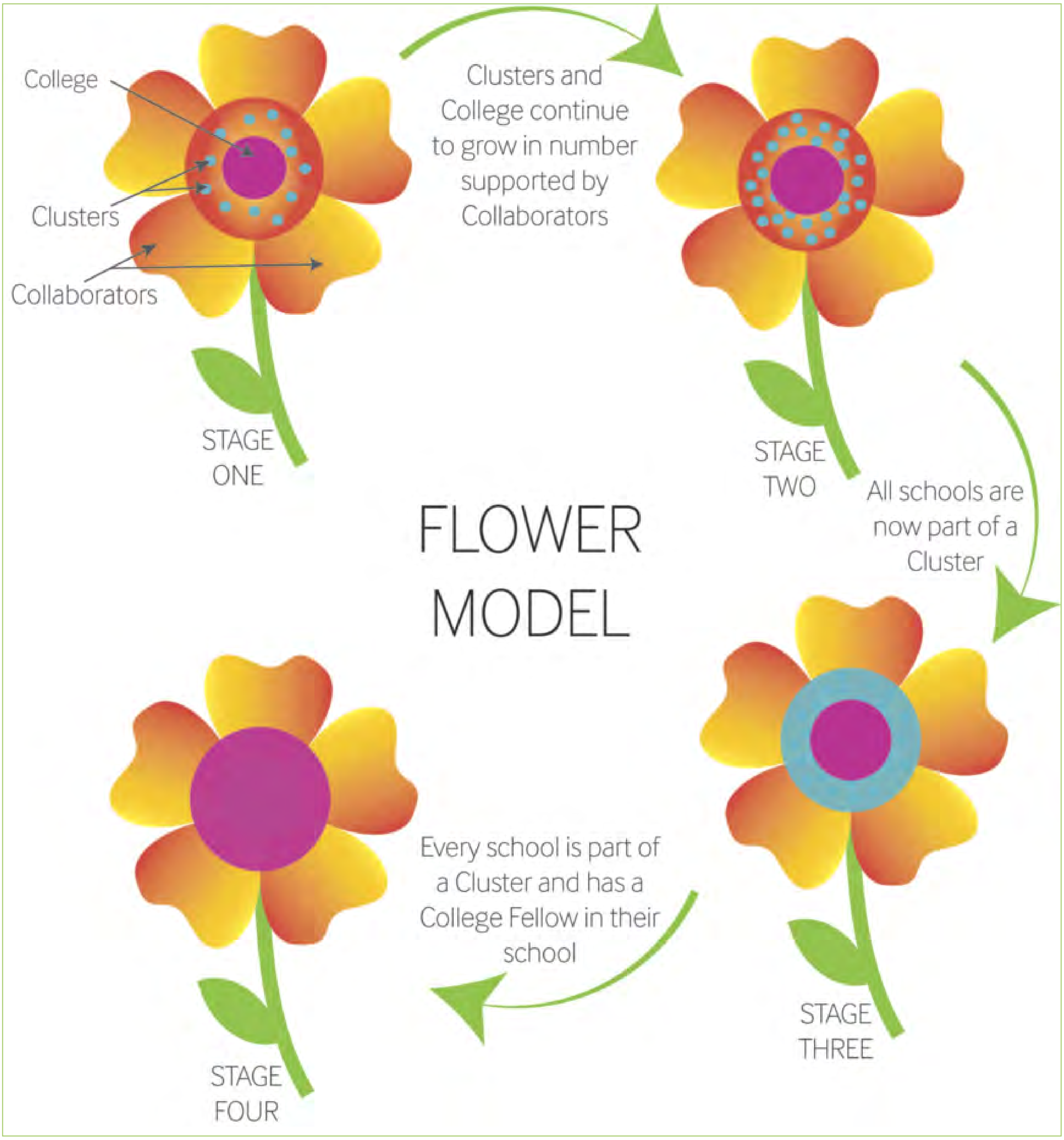


Figure 1: The flower model and its progression from a small number of clusters through to the completion of the model where all school clusters in the UK are engaging in excellent teaching of science at primary school level.

References

http://www.pstt.org.uk/SiteDocuments/doc/Primary%20Science%20Teaching%20Trust%20Overview%20Brochure.pdf Accessed 12 July 2015.

Schon, D. (1983) *The Reflective Practitioner: How professionals think in action.* London: Temple Smith

Brookfield, S. (1995) *Becoming a Critically Reflective Teacher.* San Francisco: Jossey-Bass

Dudley E. Shallcross, Kathy G. Schofield and Sophie D. Franklin, Primary Science Teaching Trust. www.pstt.org.uk

Dr. Blasto: Five to six year-old students' portrayal of a fictional science villain

■ Michael-Anne Noble ■ Christine D. Tippett

Abstract

This mixed methods study examines responses of Grade 1 students (5-6 year-olds) to a science laboratory-based problem-solving activity, and investigates students' perceptions of the gender-neutral villain presented in a science mystery. Students' drawings of Dr. Blasto (the villain) and semi-structured interviews were analysed, using checklists and open coding, to answer questions including: *How do Grade 1 students (6 year-olds) depict a character from a science activity?* Drawing on research examining drawings of scientists (see Finson, Beaver & Cramond, 1995) and Developmental Intergroup Theory (DIT, Bigler & Liben, 2007), we identified common characteristics of a science villain and possible reasons for their inclusion. As anticipated, the majority of students depicted Dr. Blasto as male. However, Dr. Blasto was unexpectedly depicted as having more than two eyes and described as possessing superpowers. Influences were mainly media portrayals of villains and heroes, rather than ideas about science.

Keywords

Developmental Intergroup Theory, Draw-a-Scientist Test, gender, stereotypes

Introduction

This study took place in British Columbia, Canada, where science is a mandated part of the curriculum, starting in Kindergarten, and consists of four strands: processes and skills of science, life science, physical science, and earth and space science (BCME, 2007). The prescribed learning outcomes for Kindergarten and Grade 1, shown in Table 1, provided the basis for a series of activities that took place during a field trip to a biology laboratory at a nearby university.

The activities were planned in addition to regular classroom science instruction and were intended to get Grade 1 students excited about science and to demonstrate that science could be seen in many different situations. The science ideas introduced or reinforced by the field trip activities also allowed the students to use mathematics and language arts skills. We could reasonably expect that the Grade 1 students participating in the study would have previously had multiple experiences in which they used their senses to observe and communicate their observations. In this study, students' observations were communicated verbally and pictorially.

The project described here was designed to examine Grade 1 students' responses to a science laboratory-based problem-solving activity, and to formally investigate students' stereotyping of the gender-neutral villain presented in a science mystery. In the activity, students collect clues from microbiological samples to determine what type of bacteria a villain, Dr. Blasto, has added to chocolate ice cream, and what type of antibiotic would be needed to kill the bacteria. The story that surrounds this problem-solving activity was written specifically for the activity and makes

Table 1: Prescribed learning outcomes for science, Kindergarten and Grade 1 (BCME, 2007).

Strand	Kindergarten	Grade 1
Processes and Skills	• use the five senses to make observations • share with others information obtained by observing	• communicate their observations, experiences and thinking in a variety of ways (e.g. verbally, pictorially, graphically) • classify objects, events and organisms
Life Science	**Characteristics of Living Things** • describe features of local plants and animals (e.g. colour, shape, size, texture) • compare local plants • compare common animals	**Needs of Living Things** • classify living and non-living things • describe the basic needs of local plants and animals (e.g. food, water, light) • describe how the basic needs of plants and animals are met in their environment
Physical Science	**Properties of Objects & Materials** • describe properties of materials, including colour, shape, texture, size and weight • identify materials that make up familiar objects • describe ways to rethink, refuse, reduce, reuse and recycle	**Force and Motion** • demonstrate how force can be applied to move an object • compare the effect of friction on the movement of an object over a variety of surfaces • demonstrate and describe the effects of magnets on different materials
Earth and Space Science	**Surroundings** • demonstrate the ability to observe their surroundings • describe features of their immediate environment	**Daily and Seasonal Changes** • describe changes that occur in daily and seasonal cycles and their effects on living things • describe activities of Aboriginal peoples in BC in each seasonal cycle

use of age-appropriate vocabulary. The villain, Dr. Blasto, is not described in any way (other than being referred to as *the arch villain, Dr. Blasto*) and is not referred to using any pronouns and, thus, could really be any gender.

Objectives

The first author had previously observed that students frequently pictured Dr. Blasto as male, as shown in Figure 1, despite the intentional lack of gender clues provided in the story, and we anticipated similar results in this study. We were interested in exploring some of the influences upon students' choices of characteristics, including gender, seen as relevant for a doctor involved in a science mystery. The research questions framing this study are:

- How do Grade 1 students (6 year-olds) depict a character from a science activity?
- What characteristics do Grade 1 students attribute to doctors, villains, and heroes?
- What prior knowledge might influence Grade 1 students' assignment of characteristics to doctors, villains, and heroes?

Figure 1: A drawing of Dr. Blasto – a typically male figure.

Theoretical framework

This study was framed using Developmental Intergroup Theory (DIT, Bigler & Liben, 2007) to offer a way to explain the influences on the attributes that students aged 5 and 6 years ascribe to doctors (academic or medical), villains and heroes, and how students apply those attributes to develop an image of a fictional science villain. According to DIT (Bigler & Liben, 2007), there are three phases involved in the formation of social stereotyping: establishment of psychological relevance, categorisation of individuals based on relevant attributes, and development of stereotypes. The first of these phases, establishing psychological relevance, has four contributing factors: perceptual discriminability, proportional group size, explicit labelling and use, and implicit use (see Figure 2). *Perceptual discriminability* refers to the ability of an individual to notice differences between individuals. Young children tend to focus on differences that are easily observed, such as gender, age and ethnicity, rather than more subtle differences such as attitudes (Bigler & Liben, 2007). *Proportional group size* refers to whether or not a group is a minority or majority in the population

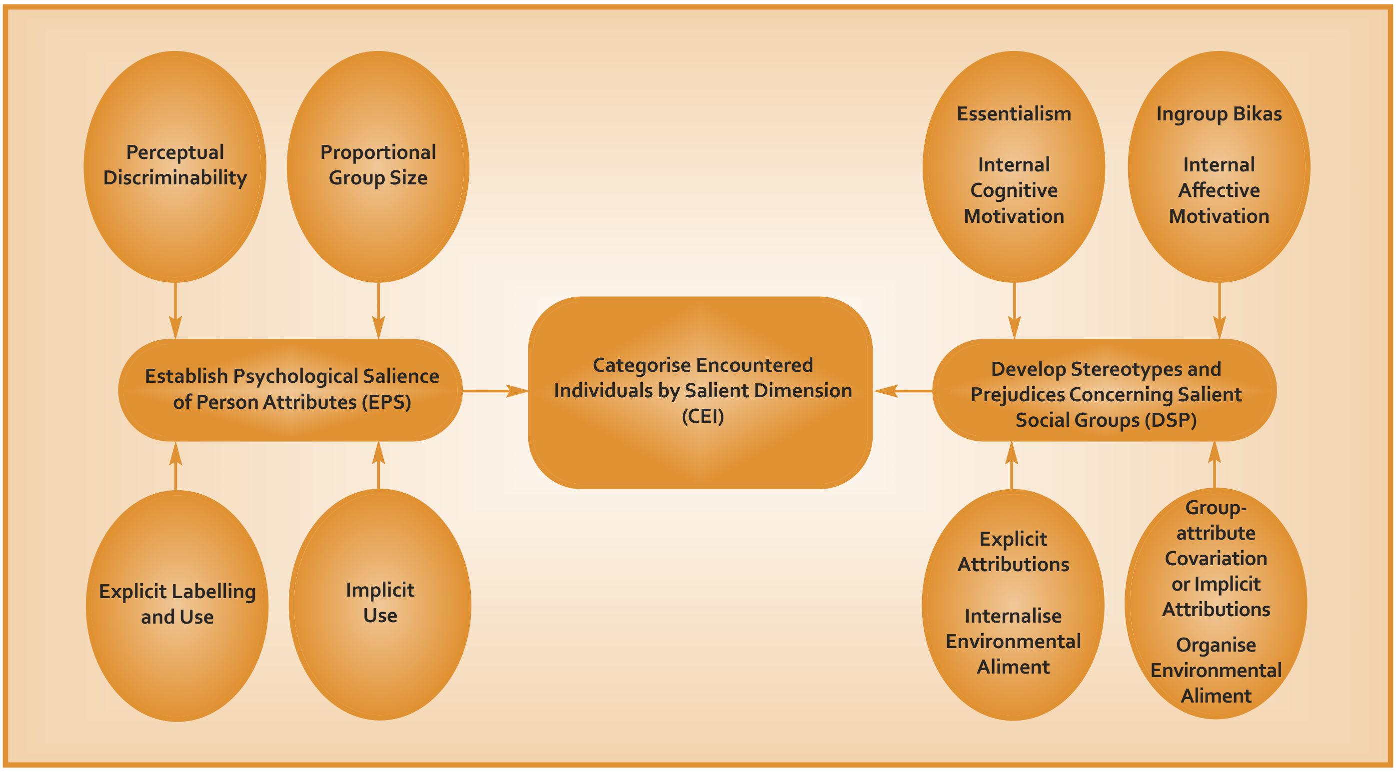


Figure 2: Developmental Intergroup Theory as described by Bigler and Liben (2007). Aspects that have potential implications for this study are perceptual discriminability, explicit labelling and use, the categorisation of individuals, essentialism, and explicit attributions.

from which the groups are drawn, with minority groups more likely to be noticed due to their contrast with the attributes of the majority, and thus more likely to be considered psychologically relevant (Bigler & Liben, 2007). *Explicit labelling* and use of groups by adults emphasises the relevance of the categories and their accompanying attributes. *Implicit labelling* results in a cognitive challenge for young children because, in the absence of understanding what attributes resulted in the categories, children focus on the attributes that they can discern (e.g. gender or age) and use them to create hypotheses about the source of the categories (Bigler & Liben, 2007).

People categorise information in order to make sense of their world and, according to constructivist learning theory (Piaget, 1975/1977), prior knowledge influences how new information is perceived; therefore, established categories will influence which attributes of the new information are noted and considered to be important. For children, who are formulating their world views based on a myriad of observations, adult cues play an important role in the construction of categories, or stereotypes, even when those cues are implicit (Bigler & Liben, 2007; DeLoache, Cassidy & Carpenter, 1987). These established stereotypes allow children to develop a list of attributes for categories such as 'man' or 'woman', so that when the category is encountered, the attributes are assumed in the absence of other information. In this study, we examine children's attributes for the categories of doctor, villain, and hero, based upon a drawing of a character in a science mystery.

One factor in the development of children's stereotypes is popular media, particularly TV shows and movies. A number of studies have examined the influence of representations of occupations on television and found that children develop gender schemata that parallel media stereotyping (Li-Vollmer & LaPointe, 2003). For example, an examination of ten popular animated films revealed a number of characteristics of villains in animated films and TV cartoons: distinctly feminine facial features, physique and hands; long flowing clothing, including capes, gowns, and cloaks; constrained body movements; a preoccupation with grooming; and a lack of manual labour (Li-Vollmer & LaPointe, 2003). It is likely that our participants' gender schemata (identification of activities and behaviours as male or female) and social stereotypes (development of attributes for doctors/villains/heroes) have also been influenced by the shows and movies that they watch, and that those schemata and stereotypes might be evident in the drawings of a science character.

Children's beliefs about gender differences with regard to occupations can influence subsequent interpretations of information (Heyman & Legare, 2004). Cognition can be affected because information that is incompatible with a child's beliefs may be ignored or recalled incorrectly (Heyman & Legare, 2004; Liben, Bigler & Krogh, 2002). It is likely that our participants' beliefs about scientists, doctors and gender may influence how Dr. Blasto is portrayed; if students believe that scientists and doctors are male, then Dr. Blasto is likely to be perceived as being male. Results from the Draw-a-Scientist Test (DAST) suggest the stereotype of a scientist as a middle-aged white male with a wild hairdo who wears a lab coat and glasses and works alone in a laboratory, often engaged in 'mad' or 'crazy' endeavours (Finson, 2002; Milford & Tippett, 2013).

The term *doctor* is considered to be unmarked in that the sex of the doctor is not indicated in the title; additionally, 'doctor' can serve as a medical or academic title. However, 'doctor' is also considered to be an occupation that is culturally stereotyped as masculine (Liben *et al,* 2002). We were interested in exploring the attributes that students had for the category 'doctor' when presented in a science scenario, and we anticipated that students' drawings of Dr. Blasto would provide evidence of those attributes. In addition, semi-structured interviews would allow us to probe students' developed categories and associated attributes more deeply.

Methods

This study was a mixed methods investigation. Quantitative approaches included the analysis of gender and other characteristics contained in student illustrations, which were scored using the Draw-a-Scientist Test Checklist (DAST-C, Finson, Beaver, & Crammond, 1995). This checklist was developed for the Draw-A-Scientist Test (Chambers, 1983), which has been used for more than 30 years to explore stereotypical characteristics of images of scientists. Qualitative approaches included conducting semi-structured interviews with students as well as collecting field notes during the focus activity. The content of the interviews and field notes were analysed using an open coding process (Flick, 2002).

Participants:

The eight participants were members of a Grade 1 class, consisting of ten boys and eight girls, who went on a full-day field trip to a local university (Royal Roads University). Six boys and two girls, average age 6 years and 9 months, returned signed consent forms and agreed to participate in semi-structured interviews. Pseudonyms that reflect the gender of the participants are used throughout this article.

Field trip and follow-up drawing activity:

The field trip consisted of a 'hands-on' science experience day. The students, accompanied by the classroom teacher, an educational assistant (EA) and three parents arrived, had a snack, and were placed into predetermined groups to rotate through five different science stations: making yoghurt, making silly putty, exploring capillary action by changing the colour of carnations, using chromatography to separate the colours in felt pens, and examining items under a dissecting microscope.

For a final group activity, the children took part in a problem-solving exercise that asked them to take on the role of scientists from the Centre for Disease Control and solve the mystery of what bacteria an imaginary villain, Dr. Blasto, had used to contaminate ice cream. While talking about the villainous Dr. Blasto, authors avoided the use of pronouns. Students circulated through four separate stations, collecting scientific evidence, and then the whole class assembled to compare clues. The authors led the students through this comparison, and the students were excited to successfully figure out the problem.

Three days after the field trip, as one of several follow-up activities including some journal writing and a discussion about what scientists do, the classroom teacher asked her students to draw pictures of Dr. Blasto.

Semi-structured interviews:

The following week, we interviewed the eight participating children individually, asking them to tell us about their drawings and their reasons for depicting Dr. Blasto as they did. We felt that verbal responses would provide additional details about the drawings and allow us to identify some of the influences on children's representational choices. Interviews were conducted in a private space at the school, while the rest of the class was engaged in independent activities (silent reading, journal writing and creating collages). The semi-structured interview questions are shown in Table 2.

Table 2: Questions for the semi-structured interviews.

1. Tell me about your picture – what is Dr. Blasto doing? What is Dr. Blasto wearing? Why did you draw [glasses, moustache, dark hair, etc.]?

2. Are doctors male or female? Do you know a doctor? Is that doctor male or female? What kinds of doctors do you know about?

3. Tell me about some villains that you have seen or heard about – what are they like? Do you know of a female villain? Who? How do you know about her?

4. Tell me about some heroes whom you have seen or heard about – what makes them different from villains? Are heroes male or female? Why do you think that?

Each interview lasted between 6 and 14 minutes, depending on the length of student responses. Responses to questions ranged from a brief *'uh huh'* to more lengthy answers: *'A doctor like somebody if a villain tries to get something to poison somebody like they did in the lab if they eat the ice cream or something they put poison in or if they get sick they go to the hospital and the nurses and doctors help them get better. Give them medicines and a lot of good stuff like medicine and stuff like that.'*

Feature	No. of Drawings	Comments
Eyes – other than two	4	2 drawings with extra eyes, 2 drawings with one eye
Cape	5	3 black, 1 blue, 1 red
Facial expression – smile	5	
Weapons or technology	5	4 guns/blasters, 2 shoes with flames or spikes, and 2 other (germ container, helmet)
Sex (male)	8	7 participants consistently referred to Dr. Blasto as *he/him;* 1 participant referred to Dr. Blasto as *he/him* and *he* or *she*, but when asked said Dr. Blasto was a girl

Table 3: Common features appearing in student drawings of Dr. Blasto.

Analysis and results

We analysed the DAST and interview data separately and then used the themes that emerged to re-examine the dataset as a whole. This approach allowed us to identify themes that may have been hidden in an initial overall analysis and to use one source of data to verify patterns and trends that emerged in the other source. We started with the drawings, which we analysed quantitatively, and then moved to the interview responses, which we analysed qualitatively.

Drawings:

Students' drawings of Dr. Blasto were analysed for items like clothing, eye wear, hair, facial expression, gender, weapons and tools, and evidence of media influences using a checklist based on the Draw-A-Scientist Test checklist (Finson, Beaver & Cramond, 1995). Common features in students' drawings were revealed by aggregating checklist results, and are shown in Table 3.

Common features of Dr. Blasto:

The five most common features or characteristics of Dr. Blasto, as depicted by the eight participants, were: being male, wearing a cape, having a large smile, having some sort of weapon or technology, and having more or less than two eyes. The drawing in Figure 3 is the most representative of the eight drawings, depicting Dr. Blasto with four of the five most common characteristics:

Figure 3: A drawing containing four of the five most common characteristics of the villain, Dr. Blasto, as depicted by participants: *'Sometimes they can be a she, but I wanted it to be a he.'*

Semi-structured interviews:

We analysed the participants' responses to the semi-structured interview questions using an open coding procedure (Flick, 2002) to identify themes. Several themes emerged, including explanations for why Dr. Blasto was drawn as a male, a common list of villains and heroes from popular media sources, and a lack of gender stereotypes with respect to doctors, villains and heroes.

Dr. Blasto: Male or female?

Based on the first author's previous experiences with spontaneous drawings of Dr. Blasto made by children who were 5 or 6 years old, combined with findings from DAST research, we anticipated that many of our Grade 1 participants would depict Dr. Blasto as male. Semi-structured interviews allowed us to investigate the reasons underlying students' depictions of the gender of a fictional science villain, and to explore the students' established attributes of the categories *doctor*, *villain*, and *hero*. The term 'doctor' was included because it was felt that the title 'doctor' might influence students' perception of the gender of the villain. However, based on the responses given by participating students, it appears that the similarities in sound between 'Blasto' and 'blast' or 'blaster' could have influenced their choice of gender for the villain. Four students included guns or blasters in their drawings and, when asked why, they mentioned that the name 'Blasto' sounded like 'blaster': '*Yeah and also I'm thinking because he blasts stuff, right? So that's why I thought of a gun and he could like shoot germs out of his gun to put in stuff like that you eat'.* This unanticipated association of the science villain's name with guns appears to have contributed to the conclusion that the villain was male (see Figure 4 for a possible chain of reasoning).

What villains and heroes were widely mentioned?

Since it seemed likely that the participants' ideas about Dr. Blasto would be influenced by participants' exposure to personal experiences (e.g. doctors) and popular media (e.g. mad scientists and villains), we explored the children's' ideas about attributes of doctors and villains. Although each child's interview responses included a list of many different heroes and villains with whom they were familiar, the same villains and heroes were identified by a number of different participants. Figure 5 shows the three main sources of participants' prior experience with villains and heroes, as well as the specific heroes and villains named during the semi-structured interviews. Of the villains and heroes mentioned by the participants during the interviews and shown in Figure 5, only three of fourteen villains are female (Catwoman, Poison Ivy and Ursula) and only four of twelve heroes are female (Black Canary, Wonder Woman, Storm and Ariel). These types of depictions may be implicitly indicating to children that villains – and heroes – are usually male (Bigler & Liben, 2007). The decision to interpret the gender-neutral Dr. Blasto science villain as male

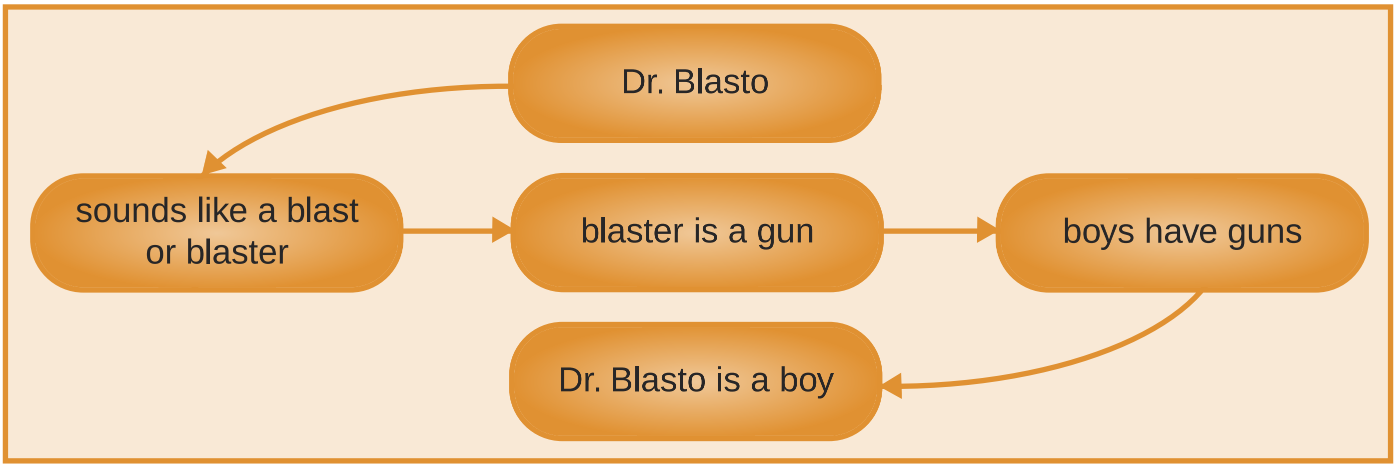


Figure 4: Possible reasoning chain resulting in students' depiction of Dr. Blasto as a male.

may also support the ideas that the attributes associated with the term *people* are the same as those associated with white male (Merrit & Harrison, 2006) and that scientists are usually represented as white males (Finson, 2002; Milford & Tippett, 2013). Merrit and Harrison pointed out that children learn to use 'he' as a gender-neutral term, which may create confusion and the perception that gender-neutral characters are male (Merrit & Harrison, 2006).

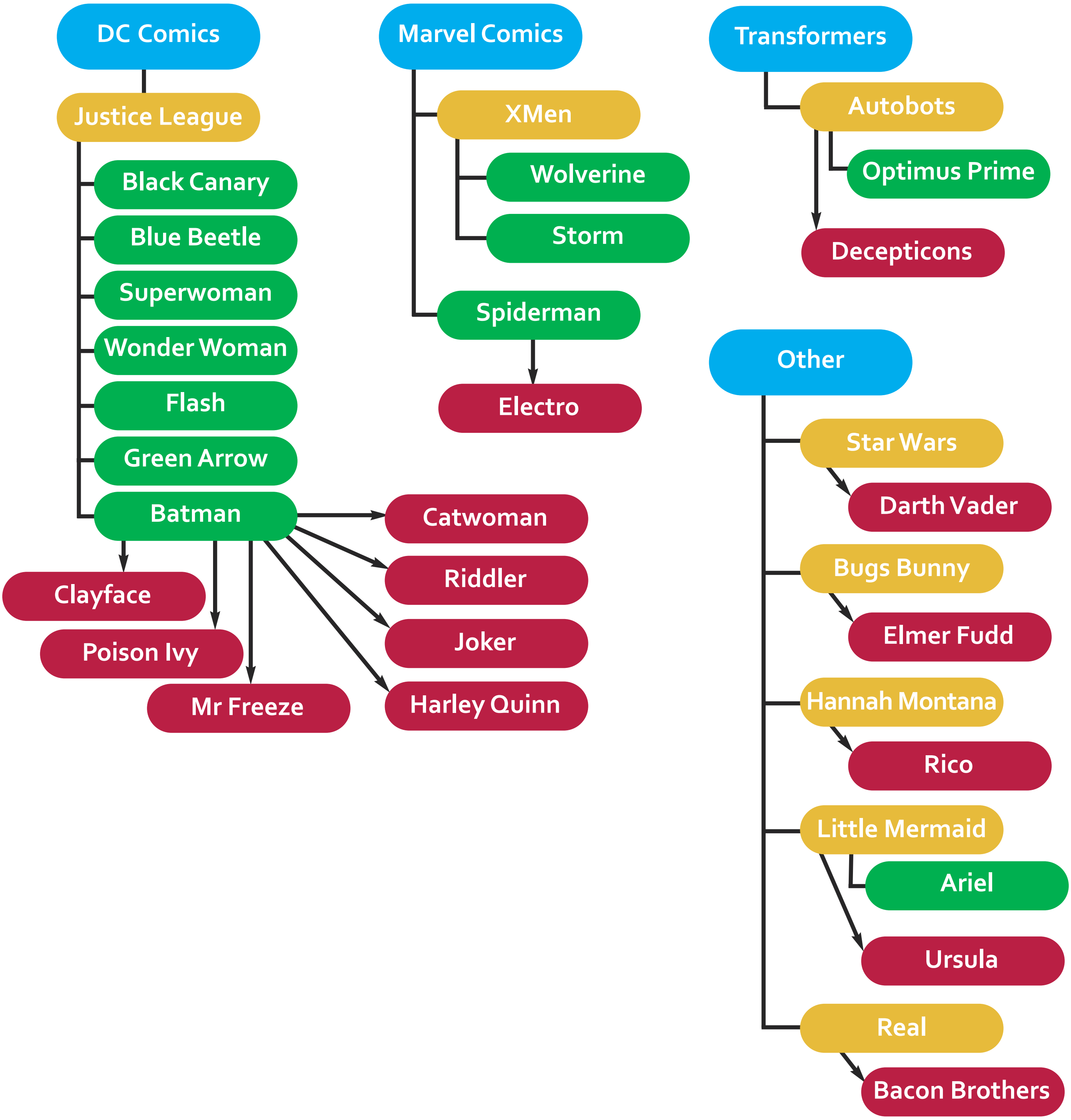


Figure 5: The relationships between heroes and villains mentioned during the semi-structured interviews. The source of the heroes and villains is shown in blue, the group or team of heroes is shown in yellow, individual heroes are shown in green, and villains are shown in red. Arrows indicate the relationship between heroes and villains.

Doctors, villains and heroes: Boys or girls or both?

We asked students whether doctors, villains and heroes were male or female in order to explore students' gender beliefs, as well as the attributes that had been developed for these categories. As seen in Table 4, most participants believed that both boys and girls (males and females) could be doctors, villains and heroes. Of the eight students who participated in the semi-structured interviews, seven were certain that doctors could be boys or girls. The eighth student, a boy whose mother was a medical doctor, thought that doctors were *'usually girls'* and that nurses were typically girls too. This finding was somewhat surprising, as we had anticipated that students would consider doctors, particularly in a science setting, as more likely to be male, thus providing a partial explanation for the depiction of Dr. Blasto as a male. However, it does not appear that the students were attributing gender characteristics to the term 'doctor', believing instead that doctors can be both girls and boys.

Figure 6: A multi-eyed Dr. Blasto.

	Doctors	Villains	Heroes
Alan	both	both	both
Brad	both	both	both
Carl	usually girls	maybe girls	both
Dave	both	both	both
Eric	both	both	both
Fiona	both	both	both
Greg	both	both	both
Helen	both	maybe girls	mostly boys

Table 4: Responses to the question 'Can doctors [villains, heroes] be boys or girls?'

Discussion

The student drawings of Dr. Blasto showed some interesting commonalities even within this small data set. We were surprised to find that four of the eight drawings showed a number of eyes other than two, as seen in Figure 6. While this finding should be further investigated, it may be related to the students' perceptions of villains as being different from themselves (students are the majority while villains are the minority).

The prevalence of the cape (see Figure 7) was anticipated, based on our own stereotypical villain images (black cape, curly moustache, lady on the train tracks), the first author's previous experiences with student drawings of Dr. Blasto, and published research results (Li-Vollmer & LaPointe, 2003). Decades of results from the DAST led us to expect that some images would show Dr. Blasto dressed in a lab coat, because the students encountered Dr. Blasto in a university science laboratory environment. However, lab coats were not prevalent in the pictures (only one out of eight participants drew a lab coat – see Figure 8). It seems that Dr. Blasto's identity as a villain was more relevant to the students than Dr. Blasto's identity as a scientist. It is also possible that, since the portrayal of a villain ('other') would likely exhibit characteristics not possessed by the individual (Bigler & Liben, 2007), Dr. Blasto would not be wearing a lab coat because the children themselves spent most of the field trip wearing lab coats.

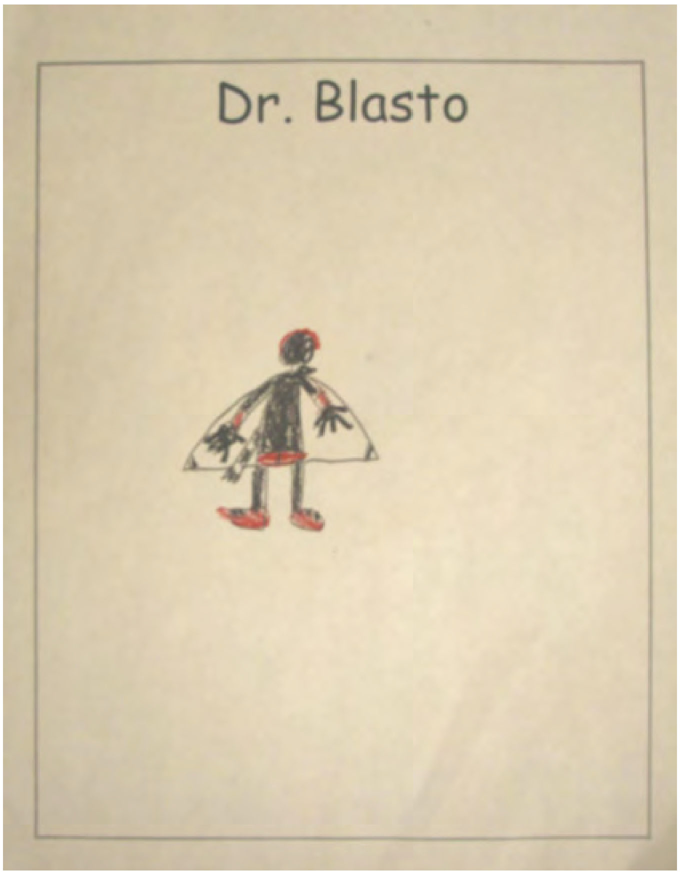


Figure 7: Dr. Blasto in a cape.

Figure 8: Dr. Blasto in a lab coat.

Another surprising result was that, in five out of the eight drawings, Dr. Blasto was smiling and had a happy smile rather than a grimace or leer. Although this result may be due to limitations in the students' ability to draw facial expressions (at least one student referred to not being a good artist), it also needs to be investigated further. Helen's 'monster superhero' sports an enormous grin that seems more in line with her positive view of her drawing and of doctors in general than with a lack of ability to portray facial features. When asked where Dr. Blasto would be if the drawing had a background, she replies: '*he would be at a monster doctor office… He would be checking people out to see if their heart is beating.*' In contrast, only three students, including Brad and Greg, made drawings in which Dr. Blasto was not smiling. Brad referred to his drawing of Dr. Blasto as having scars and sharp teeth, while Greg mentioned that his version of Dr. Blasto was 'mad', which is more aligned with the stereotype of a villain that an adult (i.e. the authors) would hold and mirrors typical results of the DAST – the mad scientist (Finson, 2002; Milford & Tippett, 2013).

Although we had anticipated facial hair in the form of moustaches and/or beards on the drawings of Dr. Blasto, based on DAST results (Finson, 2002; Milford & Tippett, 2013), none of the eight participants drew facial hair of any type and the drawing in Figure 9 is the only one to depict Dr. Blasto with dark hair. This result may show the influence of the villains and heroes in popular media – none of the villains and only one of the heroes (Green Arrow) listed in Figure 5 has facial hair. The stereotype of the moustachioed villain that the authors had anticipated is not supported by the evidence from this small group.

Although six out of eight children were certain that both girls and boys could be villains, and the other two children thought that maybe girls could be villains, seven of the children stated that their drawing of Dr. Blasto showed a male villain. This would seem to indicate that the students at this age are attributing gender as a characteristic of villains, an important step in establishing a villain stereotype (Bigler & Liben, 2007). One of the reasons for this attribution may be the overwhelming depiction of both villains and heroes as male in the popular media. Although the

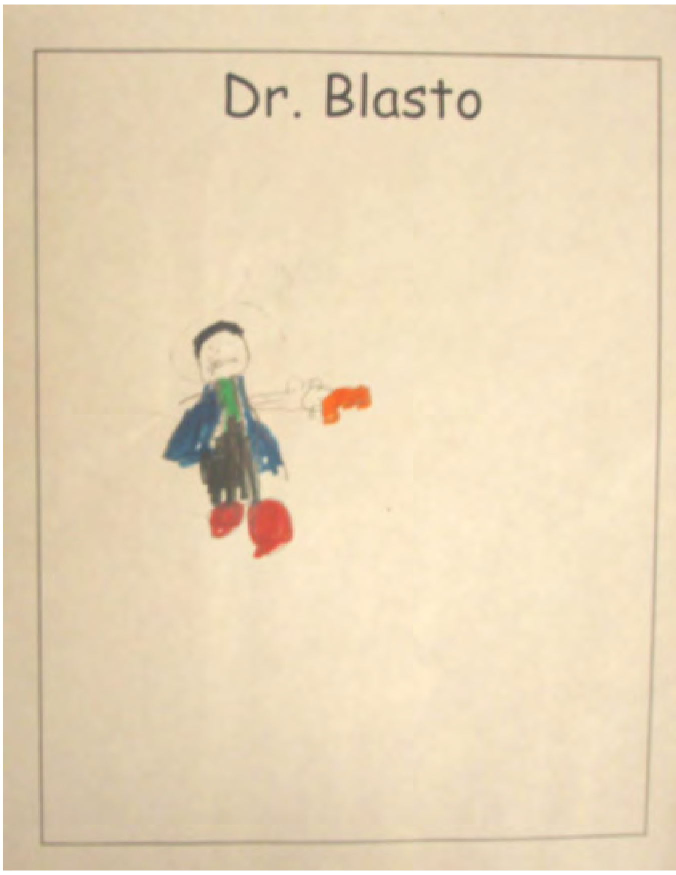


Figure 9: A dark-haired Dr. Blasto.

literature suggests that the same attribution happens with the categories of scientist and doctor, our participants appeared to believe that both doctors and scientists could be male or female.

Limitations

As with any research, there are a number of limitations to this study and the results presented here. The study involved a small group of children aged 6-7 years. With such a limited sample, the study can be considered interesting preliminary work. However, a larger sample size is needed to explore whether our results are characteristic of this age group in general or are specific to this particular group of children.

The classroom teacher noted that it would have been easier to avoid the use of pronouns when providing the instructions for the Dr. Blasto drawing exercise if she had had a script to read when introducing the activity. In retrospect, we feel that the provision of such a script would not only have helped the classroom teacher to introduce the drawing activity, but also would have avoided some unanticipated restrictions that were placed on the students' drawings. For example, students were instructed not to include a background in their drawings, although this instruction was neither requested nor anticipated by the authors. A background may have revealed further insights about what the children thought of Dr. Blasto, science villain.

It was unclear during the interviews whether students were distinguishing the idea of 'doctor' as a physician from the idea of 'doctor' as a scientist or academic. Dr. Blasto's role as the science villain and the attributes ascribed to being a villain appear to have been more important for the characteristics that the children included in their drawings than the attributes they may have given to categories of doctor or scientist. Future research will be structured to more closely examine children's ideas about physician/academic attributes.

Future research

We will be conducting a follow-up study, during which several changes will be made to the procedure in order to focus more on the attributes that children are attaching to scientists. We plan to change the name of the villain in the science mystery, not only because the title 'doctor' did not appear to be an influence on the choice of gender for the villain with these participants, but also because 'Blasto' was reported as a factor in determining gender. For example, we may use Dr. Smith or Dr. Burette, as well as a villain name without 'Dr', such as Smith or Burette.

We will also be looking to score the drawings prior to the interviews in order to more closely target the questions to emergent themes, such as multiple eyes or weapons, which may become evident. It would also be desirable to have a larger sample size than the current eight participants, and to explore whether Grade 2 students (aged 7-8) have the same doctor/villain stereotypes as the Grade 1 students (aged 6-7). We would also like to examine the issue of whether a 'bad guy' is necessarily a boy. Students often referred to villains as 'bad guys', but it is unclear whether that was an expression or a gender reference. We would like to further consider this idea in the context of the person-equals-white-male idea (Merritt & Harrison, 2006).

Implications

This study highlights the importance of explicitly discussing the appearance and actions of characters – gender-neutral characters in particular – and students' perceptions of those features when reading or viewing narrative or non-fiction texts of any length with young children. DIT (Bigler & Liben, 2007) suggests that, in the absence of such discussions, children will create hypotheses that highlight the relevance of gender in categories such as *scientist*, *doctor*, *villain* and *hero*, and these hypotheses may contribute to the development or solidification of stereotypes by emphasising masculine attributes in the absence of other information (DeLoache et al, 1987). Additionally, representations of these categories (and other characters) can be reviewed with students during and after reading, with particular attention paid to explicit and implicit labelling, categorisation and attribution. Teachers can emphasise the relevance of particular attributes for various occupations, helping to avoid the cognitive challenges imposed by implicit labelling and minimising the possibility of students identifying easily discernible attributes such as gender and age as key attributes for particular jobs (Bigler & Liben, 2007).

Another implication highlighted by the results of this study is the need to explicitly discuss student perceptions of what it means to be a scientist, doctor, villain or hero (or a member of any other group) in order to address possible misconceptions (e.g. gender or ethnicity being a defining characteristic for particular career categories). This may be a difficult step for teachers, requiring them to examine their own perceptions and preconceptions, reflecting upon their own stereotypes of various professions. However, teachers should not necessarily proceed on the assumption that students share their same views. We were certainly surprised to find that many of our perceptions of the characteristics implied by the terms 'doctor' and 'villain' were not shared by the children in this study.

Concluding remarks

There is a gap in the reported research on children, literature and stereotyping, as studies have tended to examine gender stereotyping in children's literature by quantifying the gender of characters (e.g. Turner-Bowker, 1996) or to explore the attributes ascribed to heroes (e.g. Holub, Tisak & Mullins, 2008). There is a dearth of research on children's stereotyping of villains, particularly in a science setting. It is apparent from this small study that there is a great potential for young children to form firm ideas about what characteristics are important when constructing categories, based on very few clues and assumptions. If gender becomes one of the characteristics that children ascribe to the category of scientist, it may contribute to the development and establishment of the scientist stereotype of a white male in a lab coat, leading to an inability for students to see themselves taking on that role in their future endeavours.

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When is a cow not a cow? When 6-8 year-old children draw a cow described in a story by another animal

Catherine Brugière

Abstract

Picture books are a feature of early years' classrooms. In this article, we focus on fictional drawings by illustrators that appeal to the imagination of young pupils, specifically as part of activities involving the reading of the picture book, *Un poisson est un poisson* (Lionni, 1974), and examine to what extent the children can interpret features described in the text by an animal character about another species of animal. We wanted to find out which features of the representation in words cued the children into rethinking their mental model of a cow, and which may lead pupils to adopt a different point of view about that animal from the one that they had hitherto held. The use of an illustrated story enhances the thinking of young readers about which of the cow's characteristics described by the 'fish' enabled them to represent more clearly a recognisable image of a cow, with salient features.

Keywords

Picture book, classification, fictional drawing, point of view, animal

Introduction – Children's picture books and knowledge about animals

This study focuses on another form of drawing, namely fictional drawings (Bruguière *et al*, 2007), Young children have to learn to recognise the salient observable features of a kind of organism. Observing the living world is an essential skill, which should be developed from the youngest age (Johnston (2009). It is achieved through exercising curiosity and sustained questioning with regard to the living world.

Very young children, aged 4 to 6 years, notice and find out about living things around them. When children deal with living organisms, this offers countless opportunities for understanding the natural world and contributes to their science (in this case, biological) learning (Phenice & Griffore, 2003). Johnston (2005, 2010) highlights the importance of observation in the early years for emergent scientists. It is, she claims, *'arguably the most important skill in science and certainly the first skill we develop'* (Johnston, 2005, p.33). We know from research (e.g. Inagaki & Hatano, 2002) that all children entering school have a naive biology acquired intuitively from the world and people around them. Through urbanisation and reduced freedom for children to play unsupervised, there has been a loss of opportunity for most children to readily engage with natural objects and living things in their home environment. Children in many developed countries are acquiring a *'nature deficit'* (Louv, 2006) and are often said to be increasingly out of touch with the immediate natural world. However, Patrick *et al* (2013) found that the knowledge that learners (aged 6, 10 and 15 years) have of animals shows that there is a common folk knowledge of everyday animals and plants that is held across cultures. The concepts of 'animal' and 'plant' are fundamental ontological categories, which allow children in every culture to organise their perceptions of the world in which they live (Angus, 1981).

Part of learning biological science is that pupils learn what and why they need to observe in order to be able to select, from among all the possible observable features, those that are relevant as part of describing and recognising an organism. Children hold some baseline knowledge of the categories and salient features of the organism being depicted, in order to form a judgement on the authenticity or otherwise of an illustration (Reiss, Tunnicliffe *et al*, 2002).

Drawing specimens plays a major role in the identification and recognition of observable features by young pupils, who usually enjoy this activity. Chang (2012, p.191) has shown how *'drawings also offer children milieus in which to construct knowledge'.* Therefore, drawings (of a spider or rainbow, for example) produced by children under 5 years of age may lead the children not only to discuss what they have chosen to depict, but also to go back to their drawings to improve them. According to Chang (2012), 'drawing' is taken here to be more than a simple form of expression and communication by children, which is widely used in research projects in scientific education; rather as being an integral part of question-based observation, it requires the children to ask themselves about the characteristic elements and depict them in an objectively meaningful way. This study focuses on another form of drawings, namely *fictional drawings* (Bruguière *et al*, 2007), which we have found appeal to the imagination of young pupils as part of activities involving the reading of *realistic fiction* picture books (Bruguière & Triquet, 2012). We aim to show how such drawings, which are much simplified, of observed real specimens about which children aged 6 to 8 years have some knowledge, offer them opportunities to ask questions about the identification and classification criteria of familiar animals. Our work focuses on the cow, a familiar animal to young children in France. The fictional picture book, *Un poisson est un poisson* (Lionni, 1974), is taken as a reading reference for engaging the pupils in creating their own fictional drawings.

A fictional framework for observing and drawing in sciences

In class, the task of observation is traditionally carried out through a direct or indirect observation of a target object. The child's observational drawing is a representation form of the real specimen observed and drawn, which includes features that the child notices. Young children observe and select particular features to include in their drawings. For example, four year-old children observe humans a great deal, but still draw a tadpole man. They sift out and select the most observable features, for them. Thus the observational drawing is the result of a choice in relation to the function it will be made to fulfil. However, we regard the drawings in our study as a little different, in the sense that the fictional drawings produced do not seek to represent a reality constructed as closely as possible to what is currently known, but instead a possible reality taking into account what we think we know. Malraux, quoted in Merleau-Ponty (1964), described an alternative reality to the real world arising from a *'coherent deformation of reality'.* While the observational drawing is the result of an interpretation that is dependent on the knowledge and cultural references of the subject who draws, the fictional drawing depends also on the fictional framework in which the subject who draws is placed. Hence, in our study, the fictional framework provided by the picture book, *Un poisson est un poisson*, involved asking the pupils to put themselves in the place of the 'fish' character of the story, to take his point of view, how he saw the cow, to create the drawing of a cow.

The picture book, *Un poisson est un poisson*

Un poisson est un poisson is one of the first contemporary children's picture books written and illustrated by Léo Lionni (1974). Published in a landscape format, it presents a series of double-page-spreads separated by a horizontal line, marking the surface of the water, which differentiates the aquatic environment from the land environment. This line moves during the course of the story: very high up in two thirds of the book, but then situated right at the bottom of the page when it reaches the part of the book where the overland environment is explored by the fish, before moving back up again and separating the two characters.

The story can be summarised in the following way: *'On the edge of the forest, a tadpole and a minnow swim among the weeds in a pond. The two are inseparable friends. But then, one morning, the tadpole notices that he has grown two little legs, and proudly announces that he is a frog, which his friend the minnow disputes. Once he has become an adult, he goes off to explore the overland world. Back in the pond, he tells about all the "extraordinary things" he has seen. The fish imagines the birds, cows and men just like him. Finding himself alone again, he decides to go out in search of the other world. There, on the bank of the pond, he almost suffocates. Fortunately, the tadpole-turned-frog rescues him by pushing him back into the water. He then realises that "a fish is a fish".'*

The evocation of a place 'on the edge of the forest' signals that the whole plot will be focused around this border zone between two worlds, the aquatic world and the land world, characterised by the forest. Through the events of the plot, the story dramatises biological phenomena (indirect development of the frog and direct development of the fish), which will determine not only the entire unfolding of the story but, even more so, the final outcome. In a previous study, Bruguière and Triquet (2013) showed how the statement 'a fish is a fish', which crystallises the crux of the problem and described as the story's 'golden sentence' by Tompkins (2003), can be discussed with young pupils to engage them in the potentially problematic discussion about the question of the permanence of a species during the development of an individual.

We wanted to find out if and how the use of fictional drawings, which encourage pupils to consider a point of view different from their own (the point of view of a character in the story), makes it possible to hone their thinking about the choice of which of the cow's characteristics to draw. What attributes should be depicted? For what reasons? In what format?

This questioning about the cow's characteristics seems to us all the more relevant as it concerns an animal that is familiar to young French pupils. A similar familiarity has already been shown in young New Zealanders by Bell (1981), and young Spanish pupils (Villalbi & Lucas, 1991). Strauss's research (1981), quoted by Johnston and Nahmad-Williams (2009, p.123), shows that children consider, without difficulty, the cow as an animal, with a very high and increasing score between 5 and 17 years of age (80% to 100%). The cow is, therefore, an animal that, *in principle*, does not pose any problems for the pupils and does not raise any particular questions for them. It is a vertebrate (technically a chordate) and it shares characterises with other vertebrates in the story, the fish and the frog. On the basis of these known criteria, it is a matter of engaging in critical scientific questioning, an exercise that is not an obvious one for the pupils (Ryman, 1974), but which is essential classification.

Method

The children who participated in the study attend an urban school in the Lyon area. They had already seen representations of cows in various forms (picture books about farm animals, toys, etc.) and may have seen a real cow. They were able to pick out and name a cow from other animals in a picture book.

The curriculum did not expect that these children had had teaching in classifying animals (or plants). The French curriculum does not require classification in biology until the age of 10, but we are aware that they may have learnt about the animals out of school and we were unable to ascertain this. While the children's artistic capacity varied considerably, they were all capable of situating the various characteristic anatomical features, such as four legs and a tail, on a drawing of a cow.

The teaching situation in which pupils aged 6 to 8 years were placed arises from the actual story of the picture book, *Fish is Fish* (1974), where the fish character tries hard to imagine the land-based animals described to him by the frog character (p.12). Thus we can regard this as a situation of the 'imaginary play' type, in the sense that the pupils '*involve themselves in the imaginary situation'* (Kravtsova, 2008, quoted by Marylin Fleer, 2010, p.125), through the fact that they are '*inside the play imagining themselves as some animal (a fish) within the imaginary situation (producing an imaginary drawing of a cow)'.* The choice of asking them to depict a cow is related to the fact that children are familiar with cows. Consequently, as it is very widely accepted by the children that the cow belongs to the animal kingdom, it is easier to question them about what makes their drawing depict a cow and not another animal, or in what way it does not depict a 'real' cow.

Interaction occurred in the first class session of a teaching sequence relating to animal classification with children from two classes, Class 1 (7-8 years) and Class 2 (6-7 years). This first class session, the four stages of which are shown in Table 1, took place in two different classes. Class 1 represents the treatment group that drew the cow based on the frog's description, while Class 2 represents the control group that drew the cow without the frog's description. Class 1 is taught by an experienced male teacher and Class 2 by a newly-qualified female teacher. Both teachers were actively involved for two years in the 'Science and story'[1] research group within which the teaching sequence was developed.

Our data consisted of 7 drawings from Class 1 and 21 drawings from Class 2, carried out in Stage 2. The data also included transcripts of exchanges that took place in the two classes when the pupils commented on and discussed the drawings (Stage 3). In Class 1, the teacher asked the pupils to put themselves in the place of the fish character and draw individually the cow that he imagined based on the description that the frog gave (see the text of the frog's description in Table 1*). In Class 2, the teacher asked the children to put themselves in the place of the fish character and draw the cow that he imagined without their being provided with the frog's description. Then, the fictional cow drawings were displayed on the board and discussed by the pupils with specific support from the teacher. The pupils drew in the fish's thought bubble on a photocopy of the relevant double-page spread (see illustration on Table 1). They had as much time as they wanted to do their drawings, usually between 10 and 20 minutes, and they were reminded that they would not be assessed on their drawings and that they must not copy each other.

So, the pupils were invited to take the fish's point of view by drawing what they thought the fish knew about a cow in the story. They were not observational drawings. The pupils did not draw what they actually saw in real life, but what they imagined, taking into account what they had understood of the story. As such, the drawings represented what the pupils knew about a cow (Reiss & Tunnicliffe, 2001).

The analytical framework

We devised an analysis protocol of drawings based on the story as recounted in the book in order to see to what extent the fact of providing or not providing the frog's description influences the types of fictional drawings produced by the pupils, considering the disparity in the age of the pupils. The younger pupils did not have access to the frog character's description of the cow, whereas the 7-8 year-old pupils did.

The drawings were classified by the research group according to 1) whether or not they showed a certain number of known anatomical characteristics of the cow and 2) whether or not they showed any variations in these known characteristics. We considered nine anatomical characteristics: Head (H), Body (B), Horn (HN), Ears (E), Tail (T), Legs (L), Hoof (HO), Udder (U), Spot (S). The established analytical frameworks picked up the principles defined by Reiss *et al* (2002). Each member (teachers and researchers) involved in the research gave a score for each drawing. The scores allocated were then compared and discussed collectively.

[1]The 'Science and story' research group is supported by ARC 5 (Research programme of the Rhône-Alpes Region) and is part of a Léa plan (Educational institution partnered with the Ifé-ENS of Lyon), 'questioning sciences with children's picture books'. Every month for the past 7 years, this research group has been bringing together researchers and elementary school teachers to discuss the issue of the function of fictional stories in scientific learning by young pupils.

Learning situation	**Treatment group (with the frog's description)** Class 1 (7-8 years): the frog's description of the cow is provided to pupils	**Control group (without the frog's description)** Class 2 (6-7 years): the frog's description of the cow is not provided to pupils
Stage 1: partial reading of the picture book (pps. 1–8)	The teacher reads the first nine double pages of the picture book, *Fish is Fish*, taking care not to show the author's illustrations, up to the sentence: *'And off it goes chatting away continuously, until night falls on the pond'.* The illustration on the cover sheet is hidden by a cover card.	
Stage 2: production of fictional drawings	The teacher asks the pupils to put themselves in the place of the fish character and draw the cow that he imagines based on the description the frog gives: p. 9* '"Cows," said the frog. "Cows! They have four legs, horns,eat grass, and carry pink bags of milk".' 	The teacher asks the children to put themselves in the place of the fish character and draw the cow that he imagines without them being provided with the frog's description *
Stage 3: discussion about the fictional drawings produced	The fictional cow drawings are displayed on the board and discussed by the pupils, with specific support of both classes from the teachers.	
Stage 4: complete reading of the picture book (p.9 to the end)	The pupils discover the cow drawing offered by the author, as well as the other animal depictions (bird, people, wonderful world) 	

Table 1: The learning situation in Class 1 and Class 2

The first framework dealt with the morphological and anatomical characteristics of each 'cow' drawing:

- 1st stage: the organisation plan. (If the organisation plan were that of a cow, we attributed the number 1; if it were that of another animal (fish…), we allocated the number 2).

- 2nd stage: the presence or not of each anatomical characteristic. (When the anatomical characteristic was present, we indicated the anatomical characteristic with a capital letter (B for body, T for tail, HO for hoof, H for horn, etc.)).

- 3rd stage: the presence or not of variations in the anatomical characteristics. (When there was a variation in a characteristic (position, number…), we indicated with a lower case letter the characteristic affected by the variation (h for horn, t for tail, etc.)).

Figures 1 and 2, the drawings by a boy (E) aged 7 (Class 1) and that of a girl (CH) aged 8 (Class 1) are examples of the analysis:

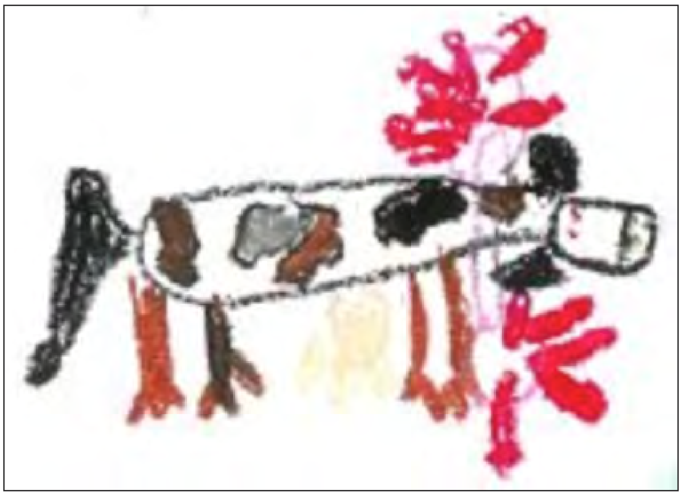

Figure 1: A drawing by E, a male pupil aged 7, from Class 1.

Figure 1 is scored 1H-B-E-T-L-U-S /u, according to the method described in the text. *(Head (H), Body (B), Ears (E), Tail (T), Legs (L), Udder (U), Spot (S))*

Figure 2: A drawing by CH, a female pupil aged 8, from Class 1.

Figure 2 is scored 2H-B-L/h-b-l, according to the method described in the text.

The second framework (see Table 2) dealt with the point of view adopted by the pupils, by considering the general appearance of the drawings. The point of view depends on the organisation plan and the variations in the anatomical characteristics made on the drawings. For example, the point of view 2 is adopted by E (Figure 1), because the organisation plan is that of a cow (pupil's point of view) and there is a variation in the number and position of the udder (fish's point of view). Point of view 1 is adopted by CH (Figure 2), because the organisation plan is not that of a cow and there are variations in the number and positions of different characteristics.

Point of view 1: the drawing represents the pupil's point of view only.
Point of view 2: the drawing represents both the pupil's point of view and the fish's point of view.
Point of view 3: the drawing represents the fish's point of view only.

Table 2: The score attributed to the point of view taken by the pupil.

Two questions guided our analysis:

- Which cow attributes were depicted and not depicted by the pupils?
- What variations did the pupils show on the cow attributes that they depicted?

For each question, we identified learning opportunities that arose.

The cow characteristics depicted or not by the pupils in the two classes (Table 3): the influence of the frog's description on the choose of anatomical characteristics

Results

Although the 'cow' drawings are very varied, as a general rule they present the same external anatomical characteristics and usually in the same proportions, except for the udders, among pupils in both classes (Table 1). In all drawings, we found a head connected to a body that had legs. The presence of a tail was frequently found (6/7 in Class 1; 18/21 in Class 2), as were spots (5/7 Class 1; 18/21 Class 2). The depiction of horns (4/7 Class 1; 12/21 Class 2) or hooves (3/7 Class 1; 9/21 Class 2) appeared averagely frequently. The presence of ears was more rare in Class 2 (2/21) than in Class 1 (4/7). The main difference between the two classes concerned the presence of udders, described by

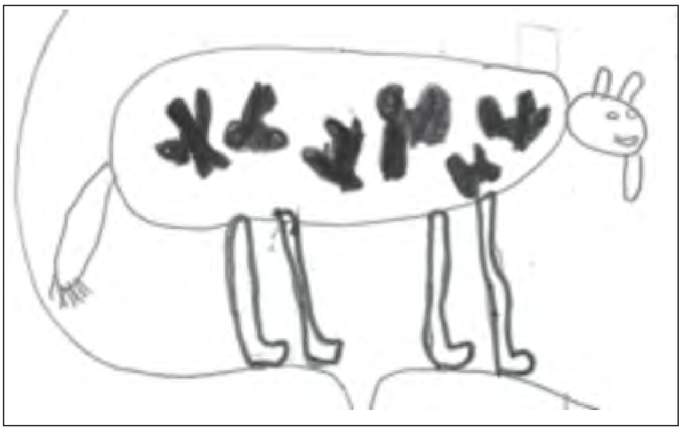

Figure 3: A drawing, without an udder, by a 6 year-old male pupil (H), from Class 2:
Score: 1H-B-HN-T-L-S

Figure 4: A drawing by a 7 year-old female pupil (C), from Class 1, showing grass:
Score: H-B-HN-E-T-L-HO-U-S/hn

	Anatomical characteristics/ environment	Class 1 (with frog's description) N = 7	Class 2 (without frog's description) N = 21
Characteristic present in the frog's description	legs	7	21
	horns	5	12
	udders	6	6
	environment (grass, plants, algae…)	6	5
Characteristic not present in the frog's description	tail	6	18
	spot	5	18
	ear	4	2
	hoof	3	9

Table 3: The anatomical characteristics and the environment presence in the 'cow' drawings from Classes 1 and 2.

Figure 5: A drawing by a 6 year-old female pupil (S), from Class 2, showing an environment (flowers): Score: H-B-T-L-U-S

the frog as 'pink bags full of milk'. Apart from the drawing by CH (Figure 2), all the drawings from Class 1 depicted udders (6/7), whereas very few from Class 2 did so (6/21). Another difference can be seen in the presence of grass (Figure 4) or algae (Figure 2) in the majority of Class 1 drawings (6/7). Few Class 2 pupils (5/21) depict the cows in an environment with grass or flowers (Figure 5).

Discussion

The anatomical characteristics provided by pupils from Class 1 are not limited to the characteristics provided in the frog's description. These pupils added missing characteristics with which they were familiar from their mental model (spot, tail, hoof, ear). These same characteristics are also in the drawings of pupils from Class 2. Class 1 pupils had no difficulty in converting 'pink bags full of milk' into the anatomical characteristic 'udder'. Here, it is apparent that the pupils have more or less incorporated into their drawings the characteristics of the Linnaean classification system, where the cow species is defined as belonging to the vertebrate and then mammal category due to the presence of four legs, udders, ear flaps and post-anal tail. Further, cows belong to the hoofed animal category, due to the presence of hooves. Not one drawing showed cows with attributes from other groups (except the drawing by CH), such as antennae.

The description 'eat grass' is not associated with an anatomical characteristic of the cow, but, instead, behaviour. This result confirms those of Tunnicliffe and Reiss (1999), which show that pupils of 5 to 14 years spontaneously describe an animal by most often citing anatomical reasons and very rarely reasons based on habitat or behaviour.
It is indeed the statement 'it eats grass' that led Class 1 pupils to incorporate the environment into their cow drawings. The presence of udders and grass in the Class 1 drawings is influenced by the frog's description.

The contrast between the absence of spots in the frog's description and the presence of spots on the drawings gave the Class 1 teacher the opportunity to ask the pupils about 'the important things' when drawing a cow. These 'important things' are, as the pupils recall, 'the horns', 'the udders' and the 'black spots', even if, as one pupil pointed out, *'it isn't shown'* (in the picture book). When the teacher asked, *'Do all cows have spots?'*, the pupils replied in unison 'no', before admitting that this characteristic can be found in most of them, and that it may or may not be present. The contingent nature of this attribute, as expressed here, opens up the possibility of asking questions about whether the other 'important things' about the cow are of a classificatory nature or not. If there are contingent characteristics, this implies that some are common and others necessary.

The point of view adopted by the pupils in the two classes: the influence of the frog's description on the point of view adopted

Results: The organisation plan (Table 4)

The external anatomical characteristics are interconnected, according to an organisation plan, more frequently as a cow type in the two classes (6/7 Class 1; 17/21 Class 2). The fish type was more rare (see Figure 2, Class 1; Figure 6, Class 2) and the dragon type was unique (Figure 7, Class 2).

Organisation plan	Class 1 (with frog's description N = 7	Class 2 (without frog's description) N = 21
cow	6	17
fish	1	3
dragon	0	1

Table 4: The organisation plan of the 'cow' drawings in Classes 1 and 2.

Figure 6: A drawing by a 7 year-old male pupil (H), from Class 2, showing a fish organisation plan: Score: H-B-T-L-S.

Figure 7: A drawing by a 7 year-old male pupil (V), from Class 2, showing a dragon organisation plan.

In these two drawings coexists a fish or a dragon organisation plan with cow characteristics.

Certain Class 1 drawings (5/7) show variations about only three characteristics: horns, tail and udder. Among these drawings, the variations are expressed through the number and position of the

Variations		**Class 1**	**Class 2**
Horn	position	3	0
	number	0	
Tail	position	1	0
	number	1	
Udder	number	1	0
	Traits number	2	
Substitutions		**Class 1**	**Class 2**
Horns replaced by fins		1	0
Cow legs replaced by tadpole legs		1	0

Table 5: The variations and the substitutions in the characteristics of the 'cow' drawings in the two classes.

characteristics associated with a cow silhouette. The horns, for example, are attached to the back (Figure 4), several udders are positioned on either side of the cow's neck (Figure 1) and the number of teats varies (between one and four). Only one drawing (Figure 2) has depicted substitutions.

Therefore, the majority of Class 2 remain focused on their point of view as pupils (point of view 1), whereas the majority of Class 2 drawings demonstrate two points of view (point of view 2): a fish point of view (by showing variations) and the pupil's point of view (with a cow organisation plan). Only one drawing (Figure 2) exclusively takes the fish point of view (point of view 3).

Discussion:

The Class 1 pupils find it easier to make a change in point of view than those in Class 2, the majority of whom remain focused on their point of view as pupils. This difference can be explained by the pupils' age, as well as by the frog's incomplete, imprecise description, which opens up different possible interpretations as explained very well by pupil CH with regard to her drawing (Figure 2): *'I imagined that he imagines that its horns are its fin and given that the frog has said "some" we can put several of them'.* She justified how she proceeded by bringing together the elements described by the author and the different attributes of the fish *'because it could have things in common with the cow'*. She imagines the horns as possibly being replaced by fins, the cow's legs by those of a tadpole *'because the fish has never seen legs other than tadpole legs'.* This work of connections set up by this pupil prompts her to imagine similarities between the structures of fish and cow species. And, yet, this activity of making comparisons, triggered by the desire to depict something unknown (the cow) through a frame of reference that is not her own (that of the fish), is that which is carried out when one looks for filiation links between species. Without positing the hypothesis of homology, this pupil sets out the idea of a certain equivalence between the different characteristics of different species, which the teacher will ask the pupils to think about at the end of the session. This investigation used the fictional drawing that brought into conflict elements of reality (according to what the drawer already knew) and elements of fiction (according to the character's supposed knowledge) and was conducive to creating new connections for thinking about or questioning a known reality. By reintroducing the notion of 'point of view', the picture book's narrative indeed made it possible to consider an observation as questionable (Bautier *et al*, 2000).

Conclusion

This case study shows to what extent the picture book *Un poisson est un poisson* (Lionni, 1974) represents an interesting resource for working with young pupils on the question of a species' characteristics. More specifically, this study shows how a familiar animal, the cow, can be reconsidered at the scientific level by 6-8 year-old pupils as soon as they are involved in producing a fictional drawing, which leads them to change their point of view. Because they are rooted in the narrative of the picture book, the fictional drawings act as a springboard for the teacher to question the pupils about what they have imagined and thereby re-question them about their scientific knowledge and their mode of reasoning.

Nevertheless, the fictional drawing works in a more limited way with the 6-7 year-old pupils, who seem more inclined to depict a cow like the cow they know than the 7-8 year-olds, who dare more easily to make variations in their cow drawings. Therefore, some 7-8 year-old pupils are capable of moving from questioning about what makes it possible to recognise a cow to questioning about the characteristics necessary for classifying it as a species. As part of the reading of a realistic fiction picture book, the use of fictional drawings offers new learning opportunities in science. Moreover, it appears that the fact of providing the author's text (here the description of the cow by the frog) encouraged the pupils' interpretive work and thereby helped them to adopt a point of view different from their own and not to limit themselves to anatomical characteristics alone. Consequently, a possible extension of this case study would be to consider under what conditions the joint use of fictional drawings and written descriptions would encourage young pupils to take into account animals in their environment.

This work could be extended to explore in greater depth the most favourable conditions for learners to recognise criterial attributes of organisms, so that such a situation works as an initial form of developing scientific thought in the greatest number of pupils and for different age groups.

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Full data are available from the author.

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Using multimodal strategies to challenge early years children's essentialist beliefs

■ Linda McGuigan ■ Terry Russell

Abstract

The work reported here forms one element of a wider study across the 4-11 age range funded by the Nuffield Foundation. The research was more broadly concerned with the development of ideas about evolution, an area of science introduced to the National Curriculum for England in September 2014. Within the study of evolution, one essential foundational idea is that of variation, as it is within-species variation that enables advantageous features to confer greater survival and breeding success on living things, whether driven by natural selection or selective breeding. This paper reports on the process and outcomes relevant to variation in living things generally, drawing on evidence from the participating children and teachers in the early years (4-7) age range. Young children tend to hold essentialist views of living things that lead them to regard all individuals within a species as identical – a view at odds with biological reality. Children's consideration of within-species variation was explored in their enquiries relating to themselves, other animals and plants. We describe how a range of tailored formative interventions, including the use of mathematical tools, proved to be helpful in supporting and developing children's understanding of variation in living things.

Keywords

Early years, variation, evolution

Introduction

The work reported here forms one element of a broader study funded by the Nuffield Foundation that examined teaching and learning of 'Evolution and Inheritance,' an area of science introduced to the National Curriculum for England in September 2014. The authors worked collaboratively with teachers and children across the primary age range to explore teaching and learning processes within this important biological domain. The domain was clustered into five interrelated themes, defined as 'Variation', 'Fossils', 'Deep time', 'Natural selection and selective breeding' and 'Evolution'. These themes were believed to have conceptual coherence, form manageable work packages and provide sufficient breadth to ensure access for children across the primary age range. Here we report some reflections and findings within the study of 'Variation' from the sub-set of early years settings (children aged 4-7 years) included in the project. The research questions of particular relevance to this paper are:

- What ideas do young children bring with them to their study of 'Variation'?
- What multimodal formative interventions can be developed in early years teachers' practices?
- How can evidence from practice be used to define optimal teaching and learning sequences?

Within-species variation is what makes changes over generations possible, so is fundamental to evolution by natural selection; without it, evolution by natural selection or by selective breeding could not occur. Yet children tend to believe all living things within a species are the same; all frogs, rabbits, oak trees, dandelions, etc. are deemed to be identical. This recurring, so-called 'essentialist', view of living things is one in which the belief is that all individuals within a species share some essential nature that makes them identical (Evans, 2001; Gelman & Rhodes, 2012). Appreciating how living things within the same species vary represents an important step along the developmental journey towards understanding of evolution. Children tend to focus on similarities between living things of the same species, as it is these that endow them with their identity. What child wouldn't believe that the tadpoles in Figure 1 are all the same? To combat this essentialist thinking, Lehrer and Schauble (2012) suggest that children (grades K - 6) can be encouraged to engage in enquiries in which they observe and measure differences in living things of the same kind.

The research sought to bring to children's attention variation in general, whether in plants, animals or parts of animals or plants and including variations in behaviour or morphology. In short, the interest was in variation in living things generally, with no particular bias of interest towards animals or plants. The choice of living things was in fact explored by prioritising organisms (or parts thereof) that practitioners or teachers found to be manageable or viable in their classroom and wider resource environment. The spectrum included, as well as farm animals (accessible through out of school visits), stick insects and tadpoles and various plants grown from seed. The exploration of children's ideas about variation thus was framed in terms of variation in living things generally, with no special priority or bias in mind favouring either plants or animals. The actual organism selected was determined by teachers' preferences and children's interests. Some of those choices made measurement possible.

Figure 1: Observing tadpoles.

Method

A collaborative Design Based Research approach (DBR, Anderson & Shattuck, 2012) was adopted for the study. DBR combines science education research and theory with educational design and development intentions to generate evidence-based and ecologically valid recommendations for practice. The enquiry and this report are qualitative in nature. It is understood and accepted that practical and applied project outcomes are more likely from the use of DBR methodology than measurable effect sizes. Because DBR deals with complex interacting variables, discrete measured outcomes tend to be relatively insignificant in the bigger picture. More weight is attached to the validation by the practitioners involved in the research and construction of support materials than to measured outcomes of pupils' assessed understanding. A core principle of DBR is to assume complementarity between the skills of researchers and practitioners, recognising teachers' existing proficiencies with the age group. The classroom relevance of outcomes also enables informed support to be offered for professional development where there is a lack of confidence. The broader enquiry across the 4-11 years age range was conducted with a group of twelve practitioners selected on the basis of their curiosity to explore the ideas that children bring to their learning. Specialist biological knowledge was not essential. Four of the twelve practitioners contributed to the evidence collected in respect of children aged 4-7 years reported here. Fourteen researcher visits were made in total to the project's four early years settings. The research followed ESRC (Economic and Social Research Council) ethical guidelines.

Year	25 Feb 2014	Feb-Apr 2014	Apr 30 2014	May-Jun 2014	Jun 30 2014	Sep-Dec 2014	Jan-Jun 2015
Activity	First core group meeting	Classroom based research, review & analysis	Second core group meeting	Classroom based research, review & analysis	Third core group meeting	Classroom based research, review & analysis	Review Validate Consult

Table 1: Project scedule.

All teachers attended three project meetings and engaged in cycles of activity that involved finding out children's ideas and developing formative, targeted interventions. Table 1 outlines the DBR schedule.

Research activities comprised: a) classroom activities managed by teachers; b) researchers' observations of practice; c) teachers' insights and practices communicated via an online (SharePoint) facility and their (Evernote) digital research diaries; and d) group meetings. Data were drawn from researchers' observations of practice, children's classroom outputs and teachers' records of their involvement. Significant information-gathering activity took place during researchers' visits to schools, including video recording, photography and collection of children's products.

The DBR approach was one in which the researchers took responsibility for setting out the general conceptual agenda. The importance of a formative approach to teaching and learning was emphasised, implying that teachers should accept the need to identify children's current understanding in order to support progression in their developing ideas. The teachers were deemed to be the early years experts and the judges of the needs and capabilities of the children they taught. Our intention was and is to build on existing confidence rather than to inadvertently disempower practitioners by the imposition of top-down views of science practices (Russell & McGuigan, 2015). Emerging practices were exchanged, critiqued and developed across the group. In this way, it was ensured that all activities were viable and appropriate for the early years age group and sat easily with generic practices.

Results

Evidence of children's expectations of within-species similarities were revealed and confirmed in their initial explorations of animals, plants and features of themselves. Reception children (4-5 years) visiting farm animals tended not to recognise the black sheep that they were observing and discussing as a sheep. Their exclamations made explicit their essentialist reasoning: *'They're not sheep! Sheep are white'.* For these children, one essential feature of sheep was a white woolly coat. Similar essentialist biases were revealed as the young children closely observed ducks. A widespread view of ducks having yellow beaks led to children failing to identify the animals that were the object of their attention as ducks (Russell & McGuigan, 2015). The wider research agenda had sensitised teachers to the essentialist issue. So it was that, in response to expressed ideas, the interactions during the visit encouraged children to observe directly some of the differences within collections of sheep, ducks and rabbits. Later and back at school, collections of hens were brought into some settings for children to observe directly.

Children initially viewed all tadpoles as homogeneous and undifferentiated. Observation using magnification brought home to them that the unhatched tadpoles showed variation and this was a surprise to them. Children's descriptions of the tadpoles' diversity included: '*That is a different shape, not round*'; '*That's got a white dot in it and the others are black*'; '*Some are brown and some are black.*' Amongst the ideas discussed for the measurement and observation of variation was plotting the number of tadpoles that hatched day by day (or by number of days after egg-laying or collection of frog spawn). This was expected to reveal a pattern (normal distribution), with a few hatching early followed by an increase in rate and then a tailing-off. Another measurement possibility was to count the emergence of legs and absorption of tails. Unfortunately, half-term breaks and fatalities intervened.

The possibility of children measuring and comparing the length of caterpillars was also discussed. In relation to stick insects, it was discussed whether it might have been possible to time and quantify skin moults. Keeping track of individuals proved extremely difficult for the age group and under the conditions in which they were kept, so that the criterion of classroom viability dictated that other foci of interest were pursued.

While planting seeds and growing plants is a ubiquitous and frequent experience in Reception and Key Stage 1 (4-7 year-olds), project children revealed an unequivocal essentialist expectation that, if the seeds they were to plant received the same amount of water and sunlight and were planted at the same time, they would all grow to the same height and produce the same number of leaves, flowers, etc. Figure 2 shows a child's drawing of how the sunflower seeds might be expected to look when the seeds grew into 'adult' plants. In conversation with a practitioner, the child explained that each plant would have two leaves and a flower. While there is a hint of variability in the height of the drawn plants, the child was of the view that the plants of the same age would all be the same. Pointing to one of the shorter plants, she explained that this plant was *'the baby'* and would therefore be smaller.

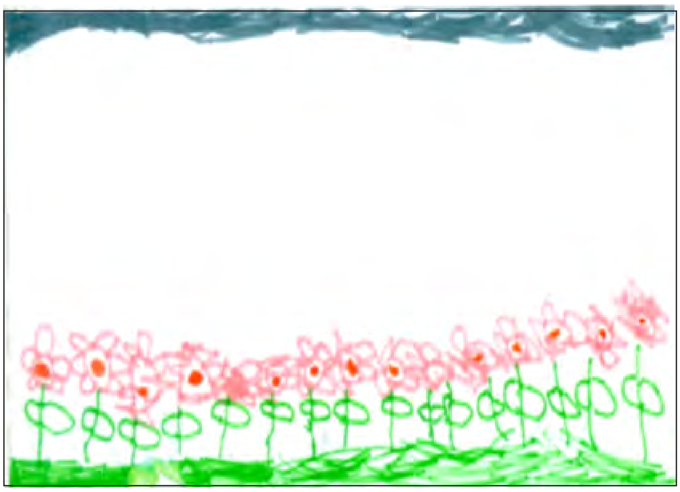

Figure 2: Child's (50 months) drawing of ideas about how sunflower seeds will grow.

Figure 3: Observing differences in the growth of pea seedlings.

A number of formative interventions were developed as the result of discussions between the project teachers and researchers. Several teachers found children engaged with a non-fiction story, *The Tiny Seed*, by Eric Carle. The narrative explores how the germination and subsequent growth of seeds is affected by environmental factors, providing a low-key and implicit introduction to the notion of survival probability – a key idea in evolutionary thinking. Reception children seemed to take the demise of the majority of the story's seeds in their stride and described some of their own experiences of neighbours' pets and birds eating seeds in their own outdoor areas.

From this starting point, children from Reception to Year 2 (ages 4-7) were encouraged to observe and compare the growth of their seeds. Across the year groups, children grew a variety of plants including carrots, peas, cress, beans, tomatoes and sunflowers. Their teachers shaped activities so that children were encouraged to look closely to observe not just similarities but also differences between collections of plants of the same kind.

In one class (aged 4-6 years), children grew peas in a wormery so that they might be enabled to observe and compare the differences not only in the shoots and leaves of the peas but also to compare root growth (Figure 3). The transparent sides provided novel opportunities for children to observe and measure differences in the individual plants' root systems. Sticky labels and marker pens were used to record length, while also taking standard measures of length in centimetres. Once a measurement strategy had been invented and agreed for one of the plant's roots, it could easily be used by children to compare each of the plants growing in the wormery.

In a Reception class (aged 4-5 years), differences between sunflower seedlings were recorded qualitatively, in drawings and paintings. As children made drawings of the changes in their sunflower seedlings, they were encouraged to observe closely, to 'look again' to check their observations and draw the leaves accurately. One child drew leaves as green lines. When asked to look closely again at the leaves, he self-corrected, changing his leaves to a curved shape. It is noteworthy that this adult's comments on drawing did not simply tell the child how the leaf *should* be drawn, or point to *a fault* or *shortcoming.* More simply, it was a matter of suggesting that further observation might prompt a change of mind or a more careful examination. Once prompted in this manner, children 'adjust their sights', perhaps even raise their standard, in line with external expectation. While each child had their own potted sunflower seedling, they were encouraged from time to time to make observations of differences across the collection of pots. Developing these careful observations and recordings helped children to identify and describe qualitative differences across the collection.

Children also recorded the number of leaves on each plant. Some looked across the data and noticed that the number of leaves on the sunflowers' stems differed. Similar observations helped children to notice that some stems varied in height while other seeds had not germinated at all. They employed their mathematics vocabulary to describe the heights of sunflower plants and used ordinal relations to sequence seedlings from shortest to tallest. With adult help, they were able to transform this row of plants ordered by height into something resembling a pictogram, putting live plants of similar height into columns. Each child added their plantlet to the 'living chart' of seedlings, observing carefully and judging where they thought each seedling should go. Typically, a child might put her plant in one column and then, following

Figure 4: Making a 'living pictogram' of plants by height (60 months).

discussion of the plant's height, move it to a different column that she thought more accurately matched the height of the plants in that set.

One child had a seed that was just showing signs of growth. He demonstrated what was happening to the seedling by his actions, curling up his body as if to show the seedling coiled up inside the seed. He put his seed pot at the very far left of the group, indicating that his plant was the smallest.

These interactions helped children to carefully compare height across the seedlings. It is from such early interactions that we might expect children to develop an awareness of the need for more systematic measures that will support judgements about variations in height.

Children were able to identify the tallest and shortest and referred to all those in the middle as 'middle-sized'. They traced around the shape of the chart with their fingers to describe the curve (Figure 4), also attempting to make the outline shape of the chart in the air when invited to do so. The child's curling up and unravelling of his body modelled the germination of the seed, while tracing the shape of the heights of the plants with a finger through the air may be the first form of recognition of the curved shape of the normal distribution or 'bell-shaped' curve. Both of these forms of representation use partial or whole body gesturing.

The activities in the Reception class reveal children using a variety of representations, e.g. drawings, paintings, speech, actions, miming, lists and charts to share their understandings. Different representational formats offer different affordances for revealing and communicating understandings. Each of the representations highlights different aspects of children's observations of variation in the sunflower seedlings. The drawings enable children to reveal ideas about differences in the colour, shape and number of leaves. Relative height can be shown in drawings, while measured height can be added in written annotations. Shape and movement might be shown in actions. Moving between (or 're-describing') representations in different ways is a metacognitive strategy that helps children to construct new understandings. The 'living chart' could not show the detail that is possible through the use of additional notations in children's drawings, but it did succeed in showing the differences in the number of seedlings at different heights. In doing so, children were introduced to the overall shape of the distribution of height of all the plants being grown by the class.

Year 2 children (6 and 7 year-olds) recorded their observations of bean seeds in individual diaries. To reflect the formative focus on children's developing ideas and to encourage observation of differences within the collection of bean seedlings, this relatively familiar experience was shaped in the following ways:

- Their teacher encouraged children to invent and decide for themselves the observations to be made and how any measurements might be taken.

- Children were encouraged to share their data with one another and to make comparisons across the collection of growing bean seeds.

Some children focused on the number of leaves, others the height of plants or the length of roots. Their drawings and writings included qualitative, semi-quantitative and quantitative observations. For example, the height of plants was compared directly, side-by-side, using non-standard (finger widths) as well as standard measures. They were eager to discuss and compare other children's seedlings with their own (Figure 5) and used the accumulating data to highlight differences between the plants. Using measurement helped children to recognise, describe and compare their

Figure 5: Comparing bean seedlings (6 & 7 year-olds).

observations of the differences within collections of plants of the same species.

In order to encourage an overview of the number of leaves on each seedling across the collection of plants grown by the class as a whole, one of the practitioners drew chalk lines as the axes of a large chart in the playground. Each child placed their growing bean seedling on the chart according to its number of leaves. Their teacher spotted some 'exaggerated' counting due to an initial desire of some children to have grown the plant with the most leaves and reminded them to count accurately, so that they could trust the results! The numbers of leaves were re-counted and plants were placed in columns according to the number of leaves grown. Children appreciated that there were fewer plants at either end and a lot more in the middle. Drawing around the assemblage of plants helped to make the shape of the distribution of number of leaves more visible and evident to children (Figure 6).

Recording measurements in 3-D charts using real plants led children to describe the shape of the distribution as *'like a volcano'* and *'like a hill'*. The term *'hill shape'* emerged as useful in helping children recognise similar patterns in their charts of measurements of their hands and feet. This provided the research group with a useful vocabulary to use in place of the more formal and obscure (to young children) 'normal distribution' – the correct term to which children might be expected to be introduced later in their learning. This shape cannot be seen by looking at individual drawings or by

Figure 6: Drawing around the assembled plants helps make the shape of the distribution more visible (6 & 7 year-olds).

comparing one plant with another. It emerged only when children aggregated the data for one attribute across the collection of plants. The early years teachers seem to have found an innovative and accessible way to introduce children to a recurring pattern in the distribution of continuous variation across a population.

Children observed and measured variability in a number of contexts, enabling them to appreciate the recurring 'hill-shaped' pattern. While encouraging children to compare physical characteristics of themselves and their peers (especially non-continuous traits such as eye or hair colour) tends to be avoided to protect children from potential sensitivities, measurements of hand and foot size tend to be acceptable and were explored in parallel in several Year 1 and 2 classes (age 5-7 years). Project teachers invited children to suggest measurement strategies and required them to explain to their peers why a particular approach should be used. Once agreement was reached, the preferred strategies were adopted by the class to provide a collection of data. While many creative measurement ideas were lost in the negotiations, a variety of measurement strategies were used across the early years sample:

- Measurements of hand span or hand length were made, along with measures of the length of foot from heel to toe.
- In some classes, string and strips of paper were matched to size of hand or foot and then measured in centimetres. In others, a ruler was used directly to make the measurement.
- Some classes drew around the hand or foot and then used rulers to measure the span or length represented in the drawing.

Children drawing around their hands and feet often added standard measurements in centimetres.

Year 2 children were surprised to find differences in their hand sizes. To help them think of these differences positively, they were encouraged to think of variations as making them 'special'. Children were encouraged to place their own cutout handprint onto a chart. In their discussions of the assembled information, some noticed that the overall shape of the chart was the same, both in their hand and foot measurements (Figure 7).

Figure 7: Measuring and describing the variability in hand span (6 & 7 year-olds).

Conclusions

Formative targeted intervention experiences formulated within the research were designed to take account of young children's essentialist reasoning. This way of thinking tends to lead children to think of living things in the same species as sharing a common 'essence'. Ideas such as *'Sheep are white'* and *'Ducks have yellow beaks'* emerging in the course of our research may serve children well as they seek to name and classify animals. However, such reasoning fails to take account of variation within species and may lead children to fail to recognise black sheep and ducks with grey beaks as members of their respective family groups. Practical strategies used by teachers in this study, in which children compared the differences within groups of living things both qualitatively and quantitatively, helped children to appreciate variation. Taking a longer view of children's science education, awareness of variation within groups of living things is an important foundation upon which the mechanisms for understanding and accepting evolution have to be based.

Within the research, some familiar early years practices were shaped towards multimodal interventions to support children's understandings. The emphasis in practice was on children representing their ideas in different modes, including speech, drawings, writings, mime, measurement, lists and charts. Encouraging the development and use of mathematical tools such as counting and measurement extended children's observations, enabling them to recognise and compare differences that may not otherwise have been possible. The multimodal practices in combination were considered to have helped children develop an awareness of variation within groups of living things. In the course of the research, some insights were gained into how mathematical tools might help children shift from ordering data in linear sequences to preparing outcomes as charts comprising physical objects. Shifts from ordinal lists to charts helped children to show and describe a collection of measures gathered by the class. Children's descriptions of the (normally distributed) pattern in data as 'hill-shaped' provide a useful basis for generating later understandings of the relationships between distribution of attributes in populations and natural selection. These representational practices are likely to be foundational for children's development of 'thinking scientifically'. Rather than 'letting go' of drawing, mime, writing, etc. as they acquire more complex mathematical and symbolic capabilities, we see developing learners continuing to explore, use and make sense of the full range of representational possibilities as a critical aspect of their scientific reasoning. Just as scientists do!

The researchers' particular interest in children's ideas about variation included the prospect of formulating developmental trajectories that describe the kinds of understandings and practices in the early years that are important to support later understanding of 'Evolution and Inheritance'. Descriptions of conceptual progress are invaluable in supporting a formative assessment approach, but must be empirically checked in settings and classrooms. The longer-term practical aspiration of our work is the production of science curriculum support materials, validated and illustrated by those early years practitioners directly involved in their formulation and grounded in their expertise. Our DBR approach combines science education research and theory with educational design and development intentions to generate evidence-based and ecologically valid recommendations for practice.

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What's inside an earthworm? The views of a class of English 7 year-old children

Sue Dale Tunnicliffe

Abstract

This paper gives the views of a class of 28 seven year-old English children (14 girls and 14 boys) about the internal anatomy of an earthworm, elicited through an analysis of their drawings of its internal structure. When their class teacher asked them to make drawings of the inside of earthworms, the children informed her about the wormery they had kept the previous year and what they had noticed, particularly that earthworms ate leaves. Nearly all the drawings showed at least an element of a digestive system and most included a brain and depiction of a heart indicating the presence of a blood system in a body cavity.

Keywords

Earthworms, internal anatomy, drawings

Literature review

Children learn about phenomena in their world from the earliest years – they are intuitive scientists. Some of their learning happens in the home and everyday surroundings, where they notice organisms in their locality as well as exotic species through various forms of media. However, although visiting museums, zoological and botanical gardens and nature centres and observing the everyday environment can bring to learners recognition of the external features of plants and animals (e.g. Patrick & Tunnicliffe, 2011), it is not evident that such observations lead to knowledge of the internal anatomy of organisms other than by referring to themselves as a template and drawing conclusions through conjecture, unless particular exhibits of anatomy are displayed.

The mental models drawn upon by the child in a drawing are representations of an object or an event. The image that the drawer is seeking to produce is formed by the process of mental modeling. Glynn & Duit (1995) state that the process of forming and constructing models is a mental activity of an individual or group. A mental model that is talked about or drawn is thus shared with others, as it is expressed in some form. In this study, the drawings are products of the drawer's imagination (Reiss, Boulter & Tunnicliffe, 2007) and memory as expressed models (Gilbert & Boulter, 2000). Visualisations are *'an essential element of teaching, understanding, and creating scientific ideas'* and depend on the person visualising, selecting the essential information and recording this, on paper, in the case of pencil-paper drawings (Tversky, 2007). Making a drawing of something tangible can help young children to shift from everyday or spontaneous concepts to more scientific concepts, whilst their construction also enables children to come to terms with spatial visualisations, interpretations, orientations and relations. Tversky claims that when children are able to create visual representations of their ideas, they are more able to work at a higher cognitive level. Of course, there are always the provisos that the child can achieve the technical and manipulative skills of drawing.

Using drawings to elicit understanding depends on how researchers can interpret the artifact produced. However, the clarity of such drawings can affect the ability of researchers to interpret them without interviewing the child and this can present difficulties and potentially lead to inaccurate interpretation of the child's intent. Drawing is difficult for younger children because of possible inexperience in using drawing tools and lack of motor skills in controlling a pencil. Symington *et al* (1981) proposed three stages in the development of children's ability to draw. The first is 'scribbling' (the youngest children) – the result being unintelligible to adults, Secondly, a child enters a stage in which drawings show very little resemblance to the object and the picture is used more as a visual representation of the child's ideas – a symbol. Thirdly, an older child shows 'visual realism', where the object and the drawings of it are identifiable and bear a closer resemblance.

Research using the drawings of children to access their ideas has become more common. Krampen (1991) suggests that one way of looking at and making conclusions about children's drawings is to focus on one figure, such as a human, and he reports that it was soon discovered that such drawings change from a 'tadpole' man to a more realistic presentation (p. 330) as the age of the child increases. Through observing and listening, children become aware of the existence of organs in their bodies (Cuthbert, 2000) and this knowledge they apply to other organisms.

However, the nature of the internal anatomy of organisms is a relatively new area of study amongst biologists. Bartoszeck and Tunnicliffe (2013) interviewed Brazilian children about their understanding of the internal structure of trees. Older children sometimes interpreted 'inside' as internal to the outside of the tree, inside the trunk and branches, reflecting Symington's perspective, which develops from scribbling to realism (Symington *et al*, 1981). These children transferred their knowledge about bones, muscles, veins and heart, features peculiar to vertebrates, to the tree, using, as Carey (1985) identified, the self as their template. More recently, Rybska *et al* (2015) worked with children in Poland who had received no formal teaching on this subject, looking at their understanding of the internal anatomy of trees.

Recently, several researchers have studied children's understanding of the anatomy of invertebrates. Bartoszeck *et al* (2011) used drawings to elicit children's understanding of the external anatomy of insects. Rybska *et al* (2015) used drawings and interviews to examine the understanding of 5, 7 and 10 year-old Polish children's understanding of the internal anatomy of snails, where it was found that the most often-drawn organ was a heart, although all the children drew organs in the fleshy part of the snail, the foot of the mollusc, not within the shell.

The understanding of the internal organs of vertebrates, beginning with bones, was elicited through an analysis of drawings by Tunnicliffe and Reiss, (1999), who then studied the understanding of organs in some vertebrate specimens from fish to humans (Reiss & Tunnicliffe, 2001). These researchers showed real specimens of a fish (fresh, a herring), a bird and a rat (preserved), before they asked the young people (ages 5 through 8 years, 14 year-olds and undergraduates), about the internal anatomy of these vertebrates.

Subsequently, Reiss and Tunnicliffe *et al* (2002) conducted an international comparison of learners' understanding of human internal anatomy, using an analysis of the drawings of 15 year-olds from a variety of countries, some Western and some from Asia. Some other research, such as a South Africa regional study (Dempster & Steras, 2014) found that children were able to identify and draw familiar organs, but not the relationships between them. Other studies, where drawings have been used that focused on people's ideas about the human body, have been summarised by Patrick (2014).

However, as Prokop *et al* (2007) point out, there are a number of factors that affect children's understanding of their knowledge of internal anatomy. Moreover, if the learner is subsequently interviewed with their drawings, they may reveal a greater understanding (Tunnicliffe & Reiss, 2014).

The study upon which this article focuses used drawings executed by children to explore their understanding of the internal anatomy of the earthworm. These children had kept a wormery the previous school year.

Their class teacher cued them in by talking about the wormery and what the worms did.

Methodology

Drawing earthworms as a class was a spontaneous event that occurred when I was observing them. They finished their French lesson early and the teacher asked me if there was anything I would like to see. I suggested this activity, which she implemented enthusiastically.

She asked the class about earthworms to establish that they understood what earthworms were. At this point, the children informed us about the wormeries they had kept the previous year. The teacher asked the children to draw, in pencil, an outline of the body of an earthworm and then insert what they thought was inside the earthworm. She did not ask them to draw a full picture and so no contexts were drawn.

We collected the drawings and noted whether the drawer was male or female.

I used the basic protocol that Tunnicliffe and Reiss (1999) devised for scoring drawings of internal anatomy, in which the researchers described stages of development of the understanding of organs and systems, and coded each occurrence with a lower case letter for an organ and capital letter for the indication of a system.

Level definition letters indicate the first letter of the relevant anatomical system	**Girls**	**Boys**	**Total girls**	**Total boys**	**Overall**
Level 1: No internal recognisable organs	2		2		2
Level 2: One+ internal organs shown at random		d,c		2	1d 1 c
Level 3: One organ in correct position	d	d,d,d	1 = d	3 (all d)	4 d
Level 4: Two or more organs in approximately correct position	ncd cd ncd ncd(r) ncd(r) nc ru nc ncd ncd (r) cd ncd	ncd ncd ncd ncd ncd ncd u n d	n=9 c=11 d=11 r=3 u=1	n=7 c=6 d=10 r=0 u=1	n=16 c=17 d=21 r=3 u=2
Level 5: One organ system	Ddc		c=1 d= 1 D=1		c=1 D=1

Table of Results

This is essentially a 5-level system:

- Level 1: No internal recognisable organs;
- Level 2: One+ internal organs shown at random;
- Level 3: One organ in correct position;
- Level 4: Two or more organs in approximately the correct position;
- Level 5: One organ system.

Although developed for vertebrates, this system was applicable to these drawings. Hence, one girl's drawing showed a gut in approximately the correct position and so was coded as a Level 3. However, this was all that was shown on her drawing.

Results

I numbered each drawing for reference (1 to 27) and made notes on the number of children who indicated and labeled the anus (2 boys, 5 girls – one of whom also mentioned the mouth), whilst others depicted the gut beginning behind the central ganglion (counted as 'brain'), but with no obvious opening.

The organs indicated on the drawings for each child were entered into the Table to show the spread of organs understood by the children and the consistency in expectations of internal anatomy.

According to the Reiss and Tunnicliffe (2001) rubric, the majority of children (18) were at Level 4. This means that they knew of two or more internal organs that are part of a system and located them in approximately the correct place. One girl (no. 3) indicated the roles of different parts of the gut ('masher', 'pusher', 'squashes it out'). Four girls drew lungs, which indicates that they have an understanding that organisms have respiratory systems but with no understanding of the mechanisms in these invertebrates.

One girl (no. 26) drew and labelled an external covering of slime. Two children (1 boy, 1 girl) drew very similar excretory tubes. Two children (drawings no. 23 and 26) indicated the presence of pores externally.

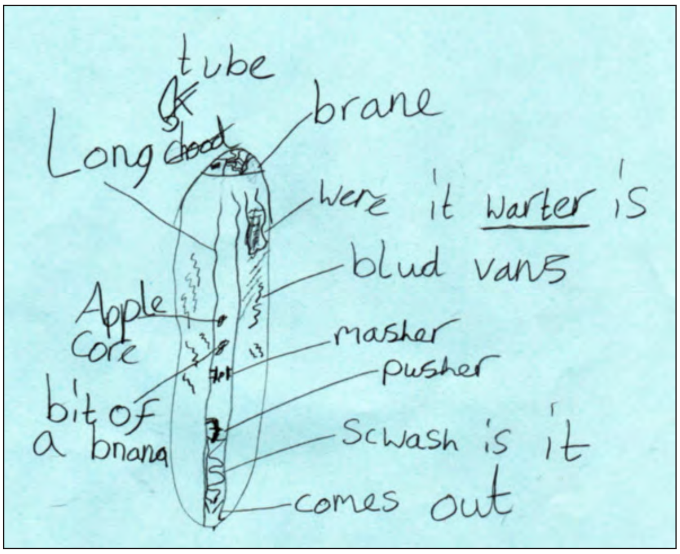

Figure 1: Inside an earthworm: 'Masher', 'pusher', 'squasher' and outlet.

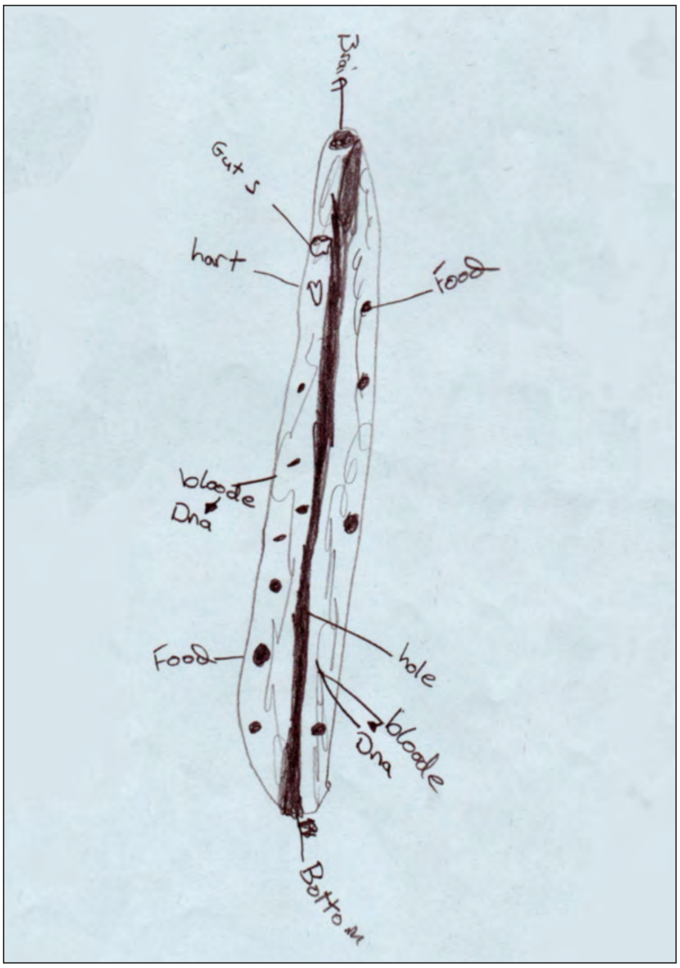

Figure 2: DNA.

Other external features drawn included segmentation, where one child (female) produced an external view showing this.

Her drawing was scored as a Level 1, as no internal organs were indicated. Drawing 20 (male) indicated bones, and three boys and two girls labelled blood as containing DNA (see Figure 2). Blood in the body cavity was indicated in a number of drawings, as was a heart, and these were scored as 'c' for an organ in the circulatory system. One girl drew a gut with an opening and an anus and was therefore scored as a 'D' for indicating a system.

A number of children drew the type of food that they knew worms ate inside their outline. One child also depicted slime, which might indicate that the child knew earthworms have moist skin (see Figure 3).

Discussion

This analysis is not as specific as when used for a vertebrate but, for example, blood was labelled, which was taken to understand the need for a circulatory system, which, indeed, is found in earthworms. They have two main blood vessels and 'hearts', and these drawings did indicate a heart. A closed circulatory system is indicated in Figure 1, which also shows a heart, albeit the iconic 'love heart' inserted in a number of drawings. The inclusion of a heart was taken as such, although the heart structure of an earthworm is not like that of a vertebrate. It is most unlikely that children of this age would have either dissected an earthworm or seen drawings or models of internal anatomy, but the drawing indicated that a closed system was present. The understanding of a circulatory system was indicated by a few drawings that labelled blood in the body cavity. Interviewing the children to find out why they had labelled this would have been useful, and I wonder if those children decided blood was present because of the colour of the body of an earthworm that they had seen? The drawer of Figure 3 labelled slime on the exterior, possibly from her direct observations of earthworms, which are moist, leading to her interpretation of 'slime'.

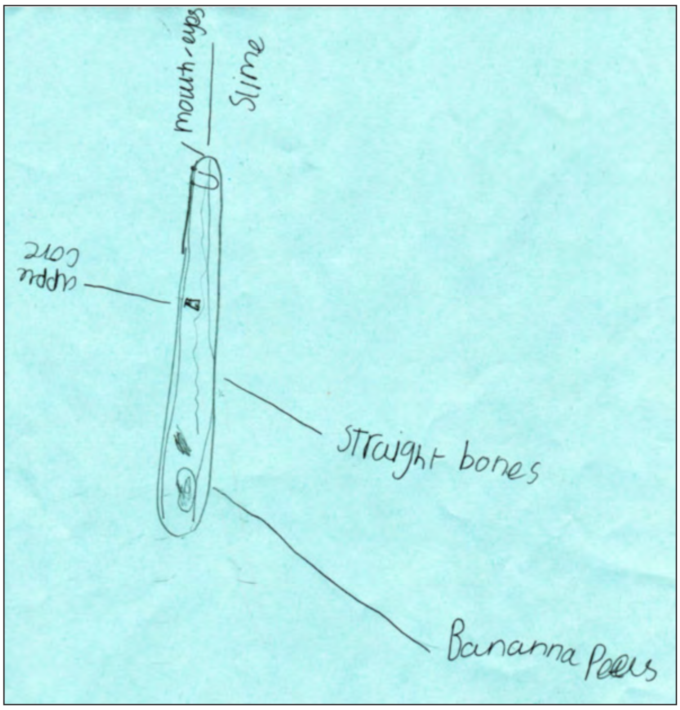

Figure 3: Bones and slime.

The drawings show that, of these children, 26 indicated at least part of a digestive system and one child drew what represented a complete system, so 27 understood the need for the presence of such a system. Seventeen children indicated a heart or part of a circulatory system and sixteen depicted a brain (although this is a central ganglion, it is in the same relative position as the vertebrate brain).

These representations on the drawings of an invertebrate suggest that the children considered what they knew they themselves possessed by way of organs and transposed this to the earthworm. Having had a wormery in their class the previous year appeared to have led them to observe the eating habits of earthworms. The class had told their teacher that worms eat leaves and so had a practically observed understanding of the gut function of earthworms. Several children revealed an understanding of the role of component parts of a digestive system.

Conclusion

These data show how effective the involvement of learners in first hand observations and activities in school are in informing their knowledge. The teacher was new to the school and had not known that the children had had a wormery the previous year before she undertook this activity. Such evidence as these data yield strengthens the case put forward by a number of educators that living organisms should be present in classrooms, because children observe them though their inherent curiosity and interest even if not formally instructed so to do.

The drawings show clearly that children use their existing knowledge of human anatomy to extrapolate systems into the earthworm, as they do for other organisms (Carey, 1985). One child labelled bones, presumably because he knew that he has bones in his body? In this study, children also used their understanding, or at least awareness, of earthworm behaviours, which was revealed in the spontaneous pre-drawing discussion about earthworms eating leaves, and which may have cued children into the fact that earthworms have a gut. However, such an assumption strengthens the case for the close observation of living things and the keeping of organisms, such as mealworms and earthworms, in classrooms where the children may make their own observations about some life processes.

Tomkins and Tunnicliffe (2007) point out that children are motivated through observing natural objects and this has a '*positive effect on attitude'* as well as their usefulness in '*developing children's knowledge, language and communication skills'*. Moreover, these biology educators make the point that the more teachers make available organisms for the learners to observe, the more these children learn from their personal observations. Such observations are fundamental to the continual development of learners' inquiry and science skills.

The next stage in this probe into children's understanding is to find out how information is acquired as children develop. Ideally, a longitudinal study following the same children from pre-school to the end of their primary years should be conducted. However, more realistically, a study of each class in a school from four to eleven years would yield further understanding of when children acquire greater knowledge of the internal anatomy of earthworms. Interviewing all the children, or a sample from each year, alongside their drawings would be the optimum study.

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Notes & News

ASE Annual Conference 2016
University of Birmingham

Wednesday 6th to Saturday 9th January 2016
Primary days: Friday 8th and Saturday 9th

This prestigious event will include some specific sessions on early years science during the Primary Days of the Conference (Friday and Saturday).

Please see the advertisement on page 54 of this issue of *JES*. More information about the Conference can be found at: www.ase.org.uk/conferences/annual-conference/

It's not too soon to book!

ESERA Conference 2015

The European Science Education Research Association (ESERA) Conference will be held at the University of Helsinki, Finland, starting Monday 31st August and finishing on Friday 4th September 2015. The event is attended by science educators, teachers and students from around Europe, with some delegates from the Americas and Australia. There are oral and poster sessions and the Conference, apart from being a very useful networking event, also provides insights into topics of current research in science education.

For more information, please visit www.esera2015.org/ or see the Facebook page at https://www.facebook.com/esera2015

12th International Conference on Hands-on Science: *Brightening our future*
Funchal, Madeira Island, Portugal

July 27th – 30th 2015

The 12th annual conference, on Hands-on Science – HSCI'2015, will provide an ideal opportunity for presentation of work, of all kinds, related to science education. The aim of the Conference is to promote an open, broad exchange of experiences on good practice, syllabus and policy matters, social factors and the learning of science, and other issues related to science education and its development, through an enlarged use of active investigative learning approaches with focus on hands-on experiments and activities to be performed in the classroom and in non-formal and formal contexts.

Early warning for 2016!

NSTA National Conference 2016

The National Conference of the National Science Teachers Association (NSTA) will be held in Nashville, Tennessee, USA, from 31st March to 3rd April 2016. For more details, please visit: www.nsta.org/conferences/

National Science Teachers Association

NSTA 2016 Global Conversations Conference

NSTA 2016 Global Conversations Conference

Call for abstracts

Science Goes Global: The Next Generation: March 30th 2016 in Nashville, TN, USA.

The International Advisory Board to the National Science Teachers Association (NSTA) is thrilled to invite submissions for both oral and poster presentations for the 2016 Global Conversations Conference. This pre-NSTA one-day Conference will be co-hosted with the national NSTA Conference in Nashville, TN. The theme for the 2016 Conference will be *Science Goes Global: The Next Generation.*

In alignment with the national Conference themes, the Global Conversations Conference encourages submissions from diverse areas of science education, including formal elementary to college science education, policy standards, best practices, novel content delivery, scientific literacy and informal education. Interspersed with the oral presentations will be round-table discussions on specific topics relevant to the international science educator community, which also allow for networking and ideas exchange. The poster presentations will be held as part of the Wednesday afternoon Conference program.

We solicit abstracts for the Conference, which will be screened by the members of the International Advisory Board. **The deadline for submission of abstracts is September 30th 2015.** We will send out announcements of acceptance by October 14th 2015. Please complete the form on the NSTA website and submit it to Oliver Grundmann, International Advisory Board Chair 2015-16, at grundman@ufl.edu

For more information and history of the Global Conversations Conference, please visit our website at http://www.nsta.org/international/

You can also obtain information about the 2016 national NSTA Conference at: http://www.nsta.org/conferences/national.aspx to get an early start on planning your attendance.

Resource Reviews

The Routledge International Handbook of Young Children's Thinking and Understanding

Edited by Sue Robson and Suzanne Flannery Quinn. Published in 2015 by Routledge, Abingdon, UK, price £140.00 Hb. ISBN 978-0-415-81642-7 (eBook 978-1-315-74604-3

This Handbook is part of the excellent Routledge International Handbook series and is an extremely good reference book for any educators interested in this vital stage of learning, where numeracy, literacy and scientific literacy blend and emerge. This volume is a contemporary and authoritative reference book, available in hardback and as an eBook (from which you should be able to purchase individual chapters).

Although an excellent reference book, this is not one designed to be read, as I did, from beginning to end! The book is organised in four parts, each apart from the final one having 10 chapters, and there is a comprehensive index as well as biographies of each chapter contributor.

Part 1 is entitled *How can we think about young children's thinking? Concepts and contexts'.* The chapters in this section discuss relevant topics, such as play, self-discovery, an exploration of children's casual explanations and issues encountered by bilingual children.

Part 2 deals with *Knowing about the brain and knowing the mind;* whilst the third Part is focused on making sense of the world, discussing a child's working theories in the early years, developing an understanding of astronomy, pretend play and its imaginative role, and narrative thinking. Part 4 focuses on *Documenting and developing children's thinking.*

Having read the book, I was quite overwhelmed, in a positive way, because so many chapters contribute to the understanding of the development of a learner's scientific literacy. My reading particularly made me consider further the role of play which, to me, seems to be a child's 'work' in experiential science in many cases of role play and other imaginative play. The chapters in Part 3 on *Making sense of the world* are relevant to science and engineering, as are some in Part 2, *Knowing about the brain* and *Knowing about the mind*. Of particular resonance to me as a science educator, apart from the information on literacy and communication in which scientists need to be proficient, was Chapter 2, *I wonder why our dog has been so naughty? Thinking differently from the perspective of play,* contributed by Elizabeth Wood. Reading this prompted me to consider science experiences, which are very much part of many play episodes with toys, everyday items and the outdoors explorations. Are such activities 'educational play', or 'freely chosen play'? This chapter provides much food for thought when considering experiential science and children's interpretations.

Chapter 37, which considers young children's drawings, is another pertinent and thought-provoking chapter for those of us using drawings in research. I would urge anyone engaged in such work with young learners to read and consider this text, contributed by Kathy Ring, in planning their investigations.

There are many other chapters with messages that are very relevant to early years science educators and researchers and I urge everyone to consult this very useful definitive text. It could be of particular use to Bachelor and Masters' students and those in teacher training, as well as researchers.

Sue Dale Tunnicliffe, Reader in Science Education, UCL Institute of Education.

About ASE

ASE and you!

Interested in joining ASE? Please visit our website www.ase.org.uk to find out more about what the largest subject teaching association in the UK can offer you!

The ASE Primary Science Education Committee (PSC) is instrumental in producing a range of resources and organising events that support and develop primary science across the UK and internationally. Our dedicated and influential Committee, an active group of enthusiastic science teachers and teacher educators, helps to shape education and policy. They are at the forefront, ensuring that what is changed within the curriculum is based on research into what works in education and, more importantly, how that is manageable in schools.

ASE's flagship primary publication, *Primary Science*, is produced five times a year for teachers of the 3–11 age range. It contains a wealth of news items, articles on topical matters, opinions, interviews with scientists and resource tests and reviews.

Endorsed by the PSC, It is the 'face' of the ASE's primary developments and is particularly focused on impact in the classroom and improving practice for all phases. *Primary Science* is the easiest way to find out more about current developments in primary science, from Early Years Foundation Stage (EYFS) to the end of the primary phase, and is delivered free to ASE members. In the past, the Committee and Editorial Board have worked closely with the Early Years Emergent Science Network to include good practice generated in EYFS across the primary phase. Examples of articles can be found at:
www.ase.org.uk/journals/primaryscience/2012

There is now an e-membership for primary schools. This enables participating schools to receive all the current benefits electronically, plus free access to the exciting *primary upd8* resources, at a discounted price. For more information, please visit the ASE website (www.ase.org.uk)

The Committee also promotes the Primary Science Quality Mark, (www.psqm.org.uk). This is a three-stage award, providing an encouraging framework to develop science in primary schools, from the classroom to the outside community, and gain accreditation for it.

The ASE Annual Conference (see the advertisement on page 54) is the biggest science education event in Europe, where over 2,500 science teachers and science educators gather for workshops, discussions, frontier science lectures, exhibitions and much more... Spending at least one day at the ASE Annual Conference is a 'must' for anyone interested in primary science.

To find out more about how you could benefit from joining ASE, please visit: www.ase.org.uk or telephone 01707 283000.