The Journal of Emergent Science

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

why & how? PRIMARY SCIENCE TEACHING TRUST

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

why & how? PRIMARY SCIENCE TEACHING TRUST

Editorial

● **Amanda McCrory**

'Most primary classes [in England and Wales] get less than two hours of science classes per week!' (*TES*, September 2017).

This headline, underpinned by *The State of the Nation report of UK primary science education* (CFE, 2017) commissioned by the Wellcome Trust, is *alarming* but yet not surprising to those of us who work in primary science education. Indeed, the outcomes of this report state that, on average, across all primary age groups, 58% of classes do not receive at least two hours of science teaching per week and this is after taking into consideration schools that take a cross-curricular approach to teaching science, as well as science trips and science weeks. In addition, 12% of the schools surveyed (1010 teachers and 902 science leaders) were not delivering weekly science lessons to any year group.

The findings of this report reinforce the view of the Confederation of British Industry (CBI) Director General John Cridland (2015, p.3), who noted that *'Science education in primary schools is being squeezed out, with too many schools struggling to teach the recommended two hours per week'.* In addition, over half the primary teachers surveyed in the *Tomorrow's World* report (2015) stated that they believed that the teaching of science in primary schools has become less of a priority. Furthermore, the outcomes of the NFER Teacher Voice Survey (Wellcome Trust, 2016) reported that, of the 740 respondents to the survey, 48% taught between 1 and 2 hours of science per week, 19% 30 minutes to one hour, and a small percentage, 4%, teaching less than 30 minutes per week. In addition to those surveyed, 24% noted that they did not teach science every week. In comparison with England's international cousins (for example, Spain, Japan and the United States), on average science is taught 8.6% of the week compared with just 6.1% in England (TIMSS, 2015; CaSE, 2017).

One then must ask the question: how do schools who don't teach science weekly or for the recommended amount of time expect the children whom they teach to make progress in their conceptual understanding of science alongside their process skills?

It is important to highlight that process skills cannot simply be honed, in an *ad hoc* fashion; they need to be planned for and developed over time, so that a child progresses in his/her process skills whilst developing a deeper understanding of scientific concepts (Allen, 2016).

When the Department for Education (DfE) abolished science statutory testing (SATs) in 2009 in favour of teacher assessment, it was recognised that this move, in part, was a response to alleviate the pressures on curriculum time and to allow children to develop an enthusiasm for science. Note that SATs testing for English and maths remained and continued to be published in league tables, along with the introduction of Level 6 testing in 2012 – although these have since been abandoned – to cater for children who were categorised as more able in English and maths (the top 2% in the country, whose work in class reflected the standard expected of a 14 year-old). Would it therefore be provocative to suggest that enthusiasm for English and maths was not an issue – as well as pressure on the curriculum, teachers or pupils – in the eyes of the Government?

The decision to abolish science SATs backfired hugely and in itself devalued the status of science; some schools – pressured by the expectations of attainment for English and maths and the knowledge that English and maths would be the focus of inspections rather than science – took more and more of the curriculum to focus on these areas: not good news for science, or for all the other subjects in the primary curriculum.

In 2013, Ofsted reported that assessment for scientific inquiry was not well developed in some primary schools (around one third) and that there was less planning for different needs in scientific inquiry than in knowledge and understanding. They argued that programmes of study of science education for all year groups should be balanced, providing opportunities for children to develop their knowledge and understanding of scientific concepts while developing their process skills; hence the changes to the National Curriculum in 2013, hopefully teaching via scientific inquiry (a statutory requirement), are now becoming embedded in primary science (when taught), but only time will tell.

However, issues for schools in providing effective science education include additional barriers. A lack of resources, the fear amongst teachers of delivering a curriculum in which they might not know the answer, to almost non-existent CPD opportunities for primary teachers as well as a lack of support and opportunities for networking with others, only compound the issue of delivering effective science education even further (Wellcome, 2017).

How can this be possible, given that science has the status of a core subject, being *'a compulsory subject in schools from 5-16'* (DfE, 2013) alongside English, maths and IT in schools in England and Wales, especially when there are bodies such as Ofsted in place to monitor the provision of education in those countries (Ofsted, 2015)?

In September 2015, a Wellcome Trust review of science in schools examined the extent to which Ofsted reports about English schools mention science. They were interested in examining this, given, as we can see, the continual concerns that science has been losing its status in many primary schools in recent years (Ofsted, 2013) and the authority and influence that Ofsted has on the behaviour of schools, with its role in verifying teaching and learning of a broad and balanced curriculum. Therefore, the Wellcome Trust asked, is the provision of science in primary schools a priority for Ofsted?

A preliminary review of Ofsted's full inspection reports from 770 primary schools found that 93% of reports did not mention science at all. This prompted a more thorough examination of recent reports using a sample of 100 schools in 2014; 73% of primary school inspection reports did not mention science, while 100% mentioned maths and English. In comparison, in Northern Ireland, 90% of primary school reports did not mention science, neither did 80% in Scotland – with only Wales bucking this trend: 100% of primary school reports undertaken in Wales mentioned science. In recent years (2016/2017), there has been an improvement in the mention rate of science in the Ofsted reports of primary schools, with 47.8% of reports referring to science, but still far behind the 99% of reports that mention maths and English (Wellcome, 2017). Disappointingly however, many of these reports mention science only in relation to how science lessons are being used to reinforce writing skills; in reality, only 15% of the reports that mentioned science focused on inquiry, therefore failing to highlight critical issues with curriculum time spent teaching science and the quantity and quality of practical work!

Therefore, how does Ofsted explain its lack of focus on the quality and quantity of provision for science when inspecting primary schools, and the conflicting message that this sends to those responsible for science provision in primary schools? It is imperative for those schools narrowing science provision to understand that a broad and balanced curriculum benefits all children in their knowledge and understanding, and skills, across the curriculum, and that they would be wise to rethink and address their provision for science education to ensure that all children receive a quality and inspiring science education.

With all this in mind, journals such as *JES* play an important role in science education for those who provide and facilitate opportunities for primary-aged children to engage in science education through providing up-to date and relevant information about developments within the field, reporting on and including the outcomes of cutting edge research, as well as providing a narrative around and about school research-based initiatives, often presented via the research articles included in the journal as well as school-based research reports provided by the Primary Science Teaching Trust (PSTT).

The *State of the Nation report of UK primary science education* (CFE, 2017) was published to mark the launch of 'Explorify', a new, free digital resource available for school science (www.explorify.wellcome.ac.uk), which is updated regularly and available online for everyone to access. We highly recommend that teachers and science educators sign on and take a look – they will not be disappointed.

In this issue, Pedreira and Márquez present an interesting paper examining a specific analysis of activities, ***Can I touch?***, designed to promote scientific inquiry for 2-6 year olds and carried out in the Natural Science Museum of Barcelona, thus promoting science education outside of the classroom.

Continuing the theme of informal learning opportunities and environments for scientific inquiry, **Wenzel and Scheersoi** critically reflect on the use of a 'Discovery Cart' to promote interest in children when exploring a wildlife park in Germany, and **Ian Milne** presents a reflective narrative about his experiences in his long career as a science educator.

Also in this edition, I present the second part of my paper, ***Scientific enquiry in primary schools,*** in which I examine and discuss the good practice taking place in primary schools in England and Wales. My colleague and Co-Editor, **Suzanne Gatt**, presents the outcomes of a small-scale research project undertaken in Malta, investigating whether or not inquiry can be effectively included in homework activities for science. Finally, there is a short round-up from Editorial Board member, **Coral Campbell**, of her recent travels around the world of emergent science.

We hope that you enjoy this edition and that, if you are a classroom practitioner, it inspires you to be creative with the opportunities that you provide for science education, both in and out of your school. Furthermore, if you are a school leader, we recognise that by reading *JES* you are unlikely to be one of the 58% mentioned in the Wellcome report; however, if you are, we would urge you to find a way to provide the children for whom you are responsible with at least the recommended time to engage in science learning. This can only benefit all!

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Enabling positive experiences in an informal learning environment for the youngest ages

● Montserrat Pedreira ● Conxita Márquez

Abstract

This article is grounded in the premise that educators of out-of-school activities ought to build environments in which children can enjoy science and have positive experiences. The idea is backed by a broad consensus on learning science in early childhood. However, how can it be validated that a child really has had a positive experience in a given activity? What evidence would allow us to confirm that an educational proposal has truly been experienced in a positive way? The article addresses these questions through a specific case analysis of the activity 'Can I touch?', offered by the Natural Science Museum of Barcelona for children aged 2 to 6. The analysis identifies three areas to validate children benefiting from a particular experience in a positive way, and leads to the identification of operational factors relevant for the design and creation of new proposals.

Keywords: Science education, childhood education, free choice learning, out-of-school learning, learning environments

'*If attitudes are formed in even the earliest stages of life, and if they have a significant influence on the child's future development, educators ought to build environments in which students will enjoy science and have positive experiences*' (Eshach & Fried, 2005, p.321).

The concept of children enjoying themselves, having positive experiences, being moved, feeling excited, etc., has been conveyed by different authors with respect to science learning. The Science Education Commission of the United States (Bell, Lewenstein, Shouse & Feder, 2009) has established that, as the first of six desirable products for its visits to centres where information about scientific education is given, '*experiencing enthusiasm, interest and motivation to learn about the phenomena of the natural and physical worlds'* is paramount to learning science. Harlen (2010) states that schools should aim to develop and sustain learners' curiosity about the world, enjoyment of scientific activities and understanding of how natural phenomena can be explained. From the field of neuroscience, the importance of emotion associated with the learning process has been identified, highlighting that *'only those things that speak to you, that captivate your attention and generate emotion can be learned'* (Mora, 2013, p.73). From the museum research realm, Falk and Dierking (2000, p.18) have written that '*All learning, even of the most logical topic, involves emotion, just as emotions virtually always involve cognition*'. Pintrich, Marx and Boyle's (1993) research about factors that influence conceptual change highlights the importance of having control over one's own actions, which means the importance of free choice in order to increase internal motivation.

The consensus among researchers on the need for children to live out positive experiences related to science learning is broad, but how can we determine that a child is really having a positive experience in a given activity or proposal? What evidence would make it possible to confirm that an educational proposal has truly been experienced in a positive way? This article addresses this research question through a specific case analysis of the activity *Can I touch?*, offered by the Natural Science Museum of Barcelona for children aged 2 to 6.

Context: *the Can I Touch?* activity

Can I Touch? is an activity for children up to 6 years of age, carried out in a specially prepared room of some 90 square metres, located near the entrance to the Natural Science Museum of Barcelona.

As these form part of a natural science museum, the objects and materials made available to the children are elements from the flora, fauna and geology of the territory. Boys and girls, in groups of up to 15, enter the room accompanied by their teachers and two museum educators. They are invited to freely explore the materials. They can go wherever they want, for as long as they want, with whomever they want, and can freely interact with the materials – on one condition; they must be careful not to damage them. The educators take a relaxed informal approach, talking with the children in soft voices and prioritising interventions with individuals or small groups rather than addressing the entire group at once.

The room is organised into a number of 'microproposals' that present the materials grouped by collections such as 'skulls', 'skins' and 'rocks and minerals' (see Figure 1), which aim to show the diversity and sensory richness of the natural world, and encourage free exploration and the emergence of children's natural curiosity (Pedreira & Márquez, 2016) .

The room arrangement for *Can I Touch?* was designed to create an environment that was both comfortable and relaxed, facilitating concentration on the specific activity either as individuals or small groups. For that reason, the 'microproposals' are distributed throughout the space in a way that allows fluid circulation but not broad movements, with discrete furnishings and decoration to highlight the value of the natural materials.

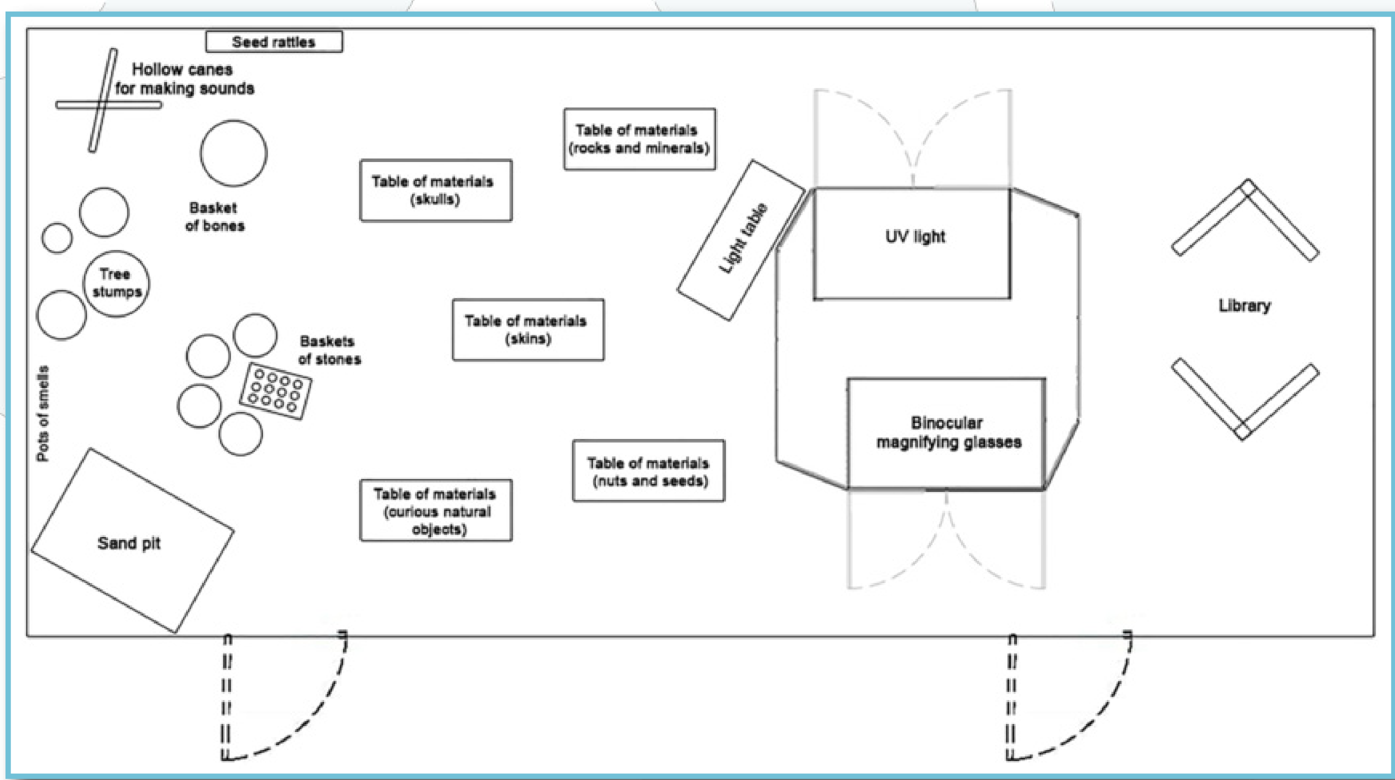
Methodology

In order to identify factors that would make it possible to determine whether the boys and girls are having a positive, exciting experience around science with the *Can I Touch?* proposal, a qualitative study was proposed, based on the observation of practice in a natural context, which highlights the richness and complexity of real situations (Rennie & Johnston, 2004), and therefore meets the purpose of this research to a greater degree.

The data have been collected through non-participatory observation of the *Can I Touch?* school visits and are shown in Table 1. The observations were made throughout the 2013-14 school year, during visits by three different schools from the Barcelona area that covered the range of ages to which the activity is offered.

The sessions were video-recorded and then transcribed for later analysis. The children's behaviour, their actions and words, as well as where they were and with whom they interacted, were faithfully noted.

Figure 1: Spacial distribution of the *Can I Touch?* activity (Source: Alba Carbonell, *Science Nest*).



Group of children[1]	Date of recording	Exploration length	Number of children	Number of sequences identified (n)
2 years	27th February 2014	42 minutes	22	59
4 years	27th September 2013	27 minutes	13	60
3, 4 and 5 years	4th April 2014	30 minutes	12	143

Table 1: Basic data from observations.

[1] The children in the 2 year-old group were born in 2011. Therefore, they would turn 3 throughout 2014, the year of the observation. The children in the 4 year-old group were born in 2009. The children in the last group were mixed from three different grade levels, and were born in 2008, 2009 and 2010.

The transcript has been organised by sequences, with 'sequence' being defined as a set of actions that follow a single logical line, a narrative unit that takes place with a number of protagonists with intentionality, and a beginning and end. When narrative units cross each other, the transcription maintains the independent storylines. It is important to bear in mind that we can ensure that the situations reflected in the transcripts have happened, but that many others may have occurred that were impossible to capture.

For the internal comparison of data, frequency analysis has been used. This is defined as the number of sequences in which a given behaviour is identified (a), divided by the total number of sequences of the session (n) (frequency = a/n).

Data analysis

To assess whether children experienced *Can I Touch?* as a positive learning experience, all the observations were reviewed, looking for evidence of enthusiasm or wellbeing and conflicts or unease (non-wellbeing). These different types of evidence have been grouped into three categories: personal expressions, peer-to-peer interaction and adult interventions.

Personal expressions:

A child's positive experience was identified through verbal expressions or gestures: laughing, smiling, humming or softly singing, different body movements or expressions of admiration (e.g. Wow! Look!). A child's negative experience was identified by such things as crying, complaining, expressing uneasiness or various disruptive behaviours: children who run or move in an agitated way, make excessive noise or use materials inappropriately.

Peer-to-peer interaction:

Favourable interactions were considered to be those that showed wellbeing in relation to others, such as situations of co-operation, when a classmate spontaneously participates and is active in another child's proposal, or those of complicity, seen in situations in which contact with the other takes on a great deal of importance: children who devote full attention to each other, imitate each other, make proposals to each other, lend materials, etc. Conflicts among the children, which emerge mainly in association with possession of the materials, are considered unfavourable interactions.

Adult interventions:

Positive experiences are understood as interventions in which the adults show themselves to be receptive to children's needs, which includes both responding to their direct requests for help, or contact with situations in which the adults show with a look, smile, or the initiation of dialogue that they attach value to what the boys and girls are doing, and encourage them to continue with what they are doing.

Non-positive experiences are understood to be those interventions oriented to keeping order and the rules of mutual respect, preventing actions of material misuse, and/or any that could affect their classmates, or having to settle conflicts between the children. Although this adult intervention clearly promotes wellbeing, it is considered a non-positive experience from the children's standpoint, as adult intervention prevents or defuses a non-positive situation.

Table 2 below features examples from each of the categories.

Blue print indicates portions of the sequence in which evidence is identified:

Personal expressions	
Wellbeing	**Non-wellbeing**
2014-02-27 _2 year-olds	2014-04-04 _3-4-5 year-olds
8:00 Boy with the large magnifying glass shouts with joy Boy: Aah, aah, aah! He stands in front of the teachers with the magnifying glass to his face, happily showing it to them. He repeats the cries, and looks for more adults to show them his discovery. Boy: Aah, aaah! I discovered..! 8:15	27:55 (...)Girl: So what will we do here? Educator 5: What do you want to do now? Girl: What can we do? Educator 5: What can we do? Boy: Are we going to be here the whole time? Educator 5: We'll be here a while longer and then we'll go to the exhibition. The boy leaves the light table. The girl insists. Girl: Can we see if there are any birds here? She points toward the other side of the nest. 28:50
Peer-to-peer interaction	
Favourable	**Unfavourable**
2014-04-04 _3-4-5 year-olds	2014-02-27 _2 year-olds
4:17 (...) They look at the rocks, one after the other, then go to the skulls. A girl looks at another girl and makes happy noises while bouncing up and down. Girl: Chye, chye, chye! She goes toward the classmate, and lowers the arm of the magnifying glass to take it off her face. She looks at her with the magnifying glass in her face. She goes bouncing away with the classmate behind her, and goes to the light table. They use the magnifying glass to look at the X-rays on display there. One leaves and, after a little while, so does the other. They go to the back of the room... 5:23	1:42 The other two boys appear to be having a conflict. One is practically on top of the other. Each has a rattle in their hand. They seem to want to pick up the same one. The boys can be heard saying: Boy: Eh, eh, eh! An adult comes and calms the one who is on top of the other. The adult says: Teacher: You have this one, he has this one. (...)

Adult interventions	
Receptive	**Maintains order**
2014-02-27 _2 year-olds	**2013-09-27_4 year-olds**
17:05 There are two boys, one girl and a female adult on the ground with the stones. (...) The boy gives the teacher a stone, who makes the gesture of weighing it and leaves it on the panel. The teacher offers the child a stone while she says: Teacher: What about this one? Does it fit? She gives the boy a stone. He fits it in. The boy gives the teacher a stone. She keeps it in her hand. The teacher tells him that the stone goes in the container, and the boy leaves it there. (...)	3:25 (...) Educator 2: Please give me that sharp object you're carrying. Boy: It pricked me! Educator 2: Right, that's why I should put it away, huh? Or better yet, why don't you take it back to where you found it? Look, Boy 10 will show you where it was. Take it back to its place. 4:00

Table 2: Examples of the different categories identified as evidence.

	evidence of a positive experience					evidence of a non-positive experience				
	Total sequences of each session	Wellbeing expression	Favourable interactions	Receptive adult	Total	Frequency	Non-wellbeing expressions	Unfavourable interactions	Adult keeps order	Total	Frequency
2 year-old group	60	30	17	18	65	1,08	8	8	12	28	0,47
4 year-old group	59	25	14	31	70	1,19	10	3	1	14	0,24
3-4-5 year-old group	143	77	22	39	138	0,97	3	19	8	30	0,21
Total	262	132	53	88	273		21	30	21	72	
Frequency		0,50	0,20	0,34	1,04		0,08	0,11	0.08	0,27	

Table 3: Number of sequences in which the described behaviour has been identified (absolute numbers and frequency).

In the wellbeing expressions, the number of times that the children show excitement associated with the materials is noteworthy. In 132 out of the 262 sequences (freq=0.50), the objects captured the attention of the children, who made verbal expressions of admiration and often felt the need to share their excitement with the others.

The expressions of non-wellbeing detected were crying (1 case), showing unease or complaining (3 cases), excessive movement (2 cases), making inappropriate noise (7 cases) or hazardous situations (8 cases). The act of identifying the cases of inappropriate noise or hazard helped to suggest measures to reduce their frequency (for example, modifying the way in which the proposal was presented).

The favourable interactions were co-operation in 7 cases and complicity in 46 cases. The most common behaviours of complicity were: devoting full attention to the other child, either taking turns, repeating the same scheme, imitating what a classmate does, watching, giving or lending materials, sharing tasks or joking. The co-operation behaviours observed consisted of filling or emptying containers together, and constructing towers or structures.

Unfavourable interactions tended to be conflicts associated with usage of materials. In the sessions analysed, the main source of conflicts was one specific instrument – the magnifying glass (11 cases out of 30). Identifying the source of conflict made it possible to think of ways to modify the proposal to avert future conflicts (increasing the number of magnifying glasses).

The analysis of the situations in which the adult was attentive to the children showed 8 cases in which the adult gave a direct response to children's demands, but 80 cases in which they were the person of reference to whom the children came to show what they were doing, to get them to smile or enter a dialogue.

In the cases observed in which the adult made the decision to intervene to make sure the rules were followed, this was done with direct, close dealing with the children involved, and the adult addressing the conflict from a calm vantage point.

These adults did not speak in a loud tone of voice, or make abrupt movements around the room. Often, a simple look from them modified the children's behaviour.

Figure 2 shows the overall numeric comparison between positive and non-positive experiences over the three sessions. It clearly shows the greater ratio of situations linked to positive experiences.

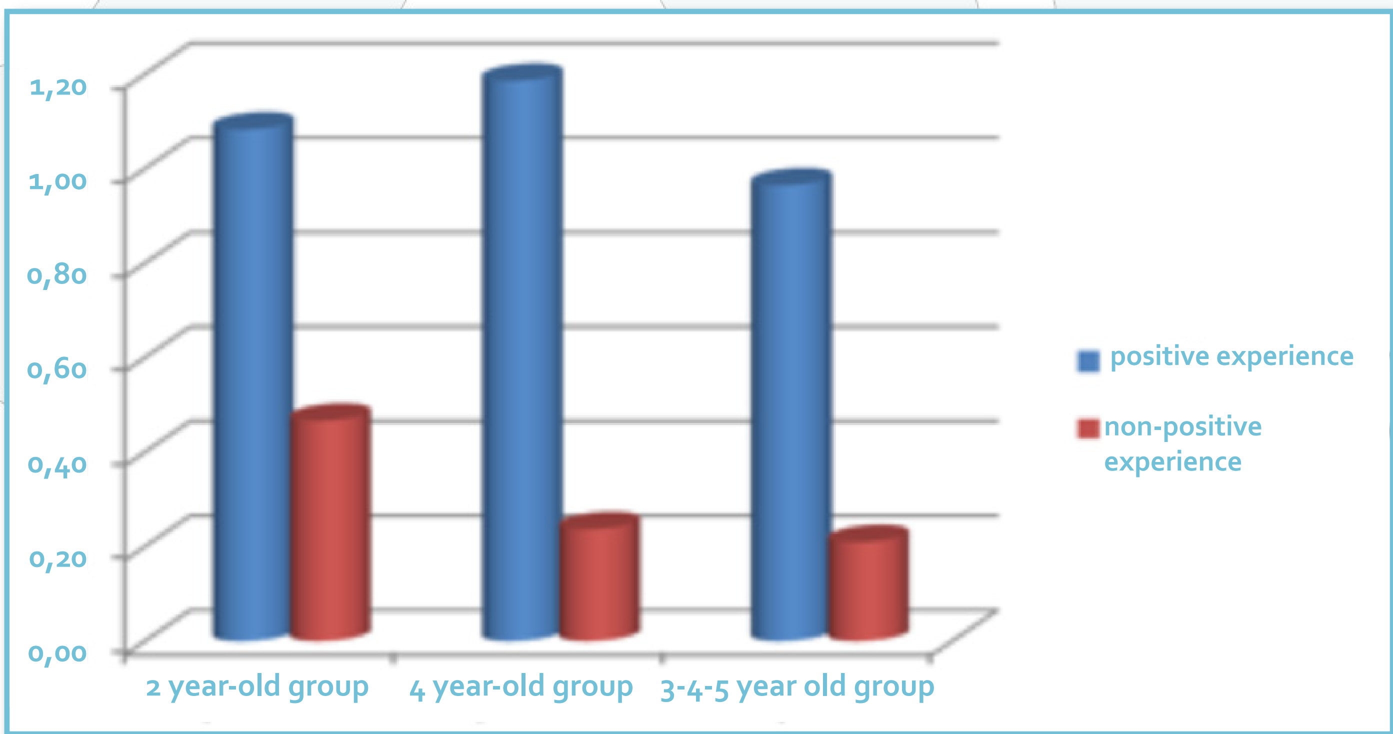
Discussion

Different authors emphasise the importance of comfortable, stress-free environments, where young children can enjoy learning about science and feel safe and secure while engaging in exploration (Rennie & Johnston, 2004) in contexts that do not generate anxiety (Mora, 2013).

It seems clear that the free-choice design of *Can I Touch?*, which does not impose itineraries or sequences but lets the children interact freely, favours experiencing the environment in a comfortable way.

Also important is the use of careful criteria regarding the 'microproposals' that are presented,

Figure 2: Comparison: positive and non-positive experiences (frequency).
(The foregoing data indicate a possible way to analyse the setting of an educational proposal for small children based on observation, and make it clear that, in the case of *Can I Touch?*, a comfortable setting is created in order for the children to enjoy science.)



both in selection and their distribution around the space. In the case of *Can I Touch?*, using 'microproposals' that do not facilitate the making of disruptive noises or the inappropriate use of the materials was a premise considered from the beginning and has been successful, as can be deduced from the low number of cases identified. Furthermore, the arrangement of 'microproposals', all around the space and properly delimited, allowing fluid traffic flow and not leading to broad, uncontrolled movement as shown by the low number of occasions in which excessive movement occurred, is also important.

The low but necessary impact of an adult who keeps order has also emerged as essential to the maintenance of the feeling of safety, as it averts undesirable situations. As shown in the sequence transcribed below, it seems that the mere presence of such an adult contributes to maintaining a favourable, safe environment and prevents most of the undesired behaviours:

2014-04-04 _3-4-5 year-olds
6:37
Boy 6 goes toward the horse skull, picks it up and lifts it. The teacher looks at him and shakes her head. Boy 6 leaves the skull where it was and goes running after her.

The data also make clear the greater importance of an adult presence as a means of guaranteeing order in groups of the youngest children. It can be supposed that the socialisation that comes from children's evolving with age helps to reduce the number of conflicts.

The materials are also important in generating a comfortable setting. A number of authors highlight the importance of collections of objects, which in the case of a natural science museum are selected, highly stimulating fragments of reality (Broadhead, 2010; Hooper-Greenhill, 1994; Shuh, 1994). Schwan, Grajal and Lewalter (2014) add, as conditions essential to the generation of an exciting experience, the discovery of new and fascinating information perceived without effort, and the stimulation of multiple senses. In the case of *Can I Touch?*, the frequent demonstrations of positive excitement associated with the objects make clear the attractiveness of the natural materials exhibited there. This attractiveness can be generally extrapolated to materials from nature, which are fascinating due to their newness as well as the richness and diversity of sensory stimuli that they offer. Careful attention must be paid to the quality of the material; it must be attractive enough to guide children's attention, action and curiosity. Quantity must not be overlooked; there must be enough to avert conflicts over possession.

Other authors refer to the importance of interactions, either from the idea that visits to science centres are a social activity in themselves (Hooper-Greenhill, 2009), or due to the relationship between interaction and construction of learning (Falk & Dierking, 2000; Tal & Morag, 2007). The data collected on the peer-to-peer interactions that occur in *Can I Touch?* make the high frequency clear, with interactions that favour a positive atmosphere being greater in number than those that do not. Given the possibility of introducing modifications in the design of the proposal to reduce conflicts of possession, which are the most relevant, it must be considered that interventions to reduce non-favourable interactions are possible.

Again, the key factor favouring positive interactions is free choice – in other words, the possibility that the children choose the materials with which they want to get involved, in which order, for how long and with whom, in an absolutely personal way, without impositions. This is a factor that reappears as something key to be taken into account when designing proposals that involve children having positive experiences.

The information collected points to the importance of the adult as interlocutor and person of reference. In all sessions, many situations occur in which the attentive response of the educators helps children's positive experience, in which the adult acts as a person of reference, a welcoming presence who promotes children's own actions, and whose look gives value to the children's actions during the activity. This is an adult who behaves discreetly, who emphasises the appreciation of each child's actions and who does not aim to impose him/herself or direct all of the children's actions at the same time, but rather is always available and attentive to the possibility of intervening to just the right degree, and facilitating scaffolding (Wolf & Wood, 2012).

One final important aspect in achieving a comfortable atmosphere is the ongoing revision of the proposal's operation, based on observations focused on behavioural evidence associated with positive and negative experiences. The identification of elements that do not favour a good atmosphere for the proposal is the first step toward introducing changes that will improve it. Therefore, remembering the adult role of observer-evaluator is essential for the continuous improvement of the proposals.

Conclusions

The research discussed herein makes possible the conclusion that, based on observation, evidence of behaviours associated with positive and negative experiences can be found. This allows the validation of the children's visit as a positive experience.

The categories defined in the article can be derived and are shown in Table 4. These categories are not meant to be an exhaustive or universal list, as they correspond to a specific case, though it is understood that they could be the basis of other research. On another note, the integration of the results obtained in *Can I Touch?* with the different ideas contributed by the research makes it possible to identify key factors that have to do with achieving an environment in which to enjoy science at the youngest ages, and that can therefore be useful when implementing new activities. They are listed in Table 5.

Positive experience is very important in promoting positive attitudes toward science, but it also seems reasonable to think that such situations are highly educational and have great learning value. This article has outlined a way to identify, in the case of *Can I Touch?* or any other science proposal for children of the youngest ages, analysis categories with which to validate that an educational proposal is lived as a positive learning experience, and key working factors that influence this experience have been determined. Future research must address the learning that takes place in these conditions.

Table 4: Analysis categories to validate, based on observation of a natural situation, whether an educational proposal generates a learning atmosphere lived as a positive, pleasant experience.

Personal expressions	**Wellbeing:** laughing, smiling, humming or softly singing, different body movements or expressions of admiration **Non-wellbeing:** crying, complaints or various disruptive behaviours (broad, abrupt movements, exaggerated noises or dangerous use of the materials)
Peer-to-peer interactions	**Favourable:** co-operation, complicity, (children who devote full attention to each other, imitate each other, make proposals to each other, lend materials, etc.) **Unfavourable:** conflicts over possession
Adult interventions	**Being receptive to children's needs:** responding to their requests, showing that they appreciate what the children do **Keeping order:** preventing misuse of material, pacifying conflicts between children

Factors	Characteristics	Contributions
Free-choice operation	Free access to materials Non-sequential Non-direction of adult	Positive atmosphere: there are no impositions to follow. Therefore, everyone can follow their own preferences in terms of activity and classmates. Favours interactions.
Objects and materials	Attractive, diverse material (quality) Appropriate number of materials (quantity)	The attractiveness of the material guides children's attention and causes positive emotions to emerge. The appropriate number minimises conflicts due to possession.
'Microproposals'	Distributed in a balanced way throughout the space Non-disruptive proposals	Proper arrangement of the 'microproposals' prevents broad, abrupt movements. Proper selection prevents noise, hazards or undesired conduct.
Role of the adult	Discreet and respectful, but firm in preventing undesirable conduct Attentive and receptive of children's needs Observer-evaluator	Keeps order, prevents undesired behaviour. Provides a response to children's needs. Attaches value to what children do. Favours the analysis and evolution of 'microproposals' and the space in general.

Table 5: Key factors in building a learning environment for children to enjoy science at the youngest ages.

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Exploring a wildlife park with the 'Discovery Cart' – Materials to promote interest among primary school classes

● Volker Wenzel ● Annette Scheersol

Abstract

When organising field trips, teachers often have to decide whether they want to book a tour or lead the students themselves. The present study investigates how teaching resources can best be designed to spark and maintain students' interest during a self-led tour, without time-consuming preparation on the part of the teachers. As an example, a handcart stocked with visual and hands-on materials (the 'Discovery Cart') on the topic of wildlife biology was developed for primary school groups, based on the Person-Object Theory of Interest (Krapp, 1998, 2005).

The materials were developed using the design-based research approach (DBR Collective, 2003): first, theory-based design features (design hypotheses) were developed. These were then tested with school groups using concrete materials in order to analyse their effect. Through a formative evaluation, the materials were gradually improved and expanded. Lastly, the finished Discovery Cart underwent a final test in a summative evaluation with 23 school classes (N=339). In addition to developing practical materials, the study's findings also provide new information about how situational interest is created among primary school students at out-of-school learning sites.

Keywords: Wildlife park, teaching resources, interest development, primary school

Introduction

Wildlife parks, such as zoos, botanical gardens and museums, are especially important out-of-school learning sites because of their educational mission, both for the public and for schools (Harms, 2013). In addition to purely conveying specialised knowledge, they support affective and social communicative learning objectives through first-hand, original encounters (Favre & Metzger, 2010).

When organising field trips, teachers often have to decide whether they want to book a tour or lead the students themselves. There are good arguments for both options: while professional tours are generally given by very well-trained specialised staff, teachers leading a tour by themselves are already familiar with the students' range of abilities, which allows them to tailor the presentation to the audience. In addition, it gives them the flexibility to take breaks as needed or to rearrange the tour at a moment's notice, which can be especially important for the heterogeneous primary school grades.

In the past, the Weilburg Wildlife Park (Hesse, Germany) was usually visited by primary school classes without an official tour and without any special instructional aids. Therefore, the objective of the present study was to investigate how a teaching concept and the associated supporting materials could be designed to allow teachers to provide their students with a tour that both sparks their interest and provides correct biological information. In order to generate research findings on interest research, along with the evidence-based development of materials and the teaching concept, the design-based research approach (Design-Based Research Collective, 2003) was adopted.

Theory

Many studies confirm the importance of interest for learning and for student performance (Ainley *et al*, 2002; Schiefele & Schreyer, 1994; Schiefele, 1996). In addition to acquiring specialised skills, the goal in primary education is to develop and foster interest, curiosity and attention (Hessisches Kultusministerium, 2007). Interest has been defined as a person-object relationship that is characterised by emotional, cognitive and value-based features (Schiefele *et al*, 1983; Krapp, 1998). A distinction is made between individual interest that is a relatively stable and enduring orientation towards a certain object or subject area, and situational interest that arises in a current (learning) situation and is bound to that situation (Krapp, 1992). This makes situational interest (SI) particularly useful for analysing teaching concepts and materials at out-of-school learning sites (Lewalter & Geyer, 2009).

In developing SI, a distinction is made between an initial 'Catch' phase, when attention is drawn to a certain object or theme and curiosity is awakened, and a subsequent 'Hold' phase, when the person wishes to intensify the relationship with the object (Mitchell, 1993; Hidi & Renninger, 2006). According to the self-determination theory of Deci & Ryan (1993), in addition to students' personality traits such as the self-concept of their own abilities (Lohrmann *et al*, 2010) and expectations of self-efficacy (Bandura, 1997), the three basic psychological needs of experiencing competence, relatedness and autonomy also play an important role in creating and developing SI. Moreover, recent findings highlight the significance of these basic needs for generating interest among primary school children on field trips (Scheersoi & Tunnicliffe, 2014). Additional factors that positively influence the development of interest, such as working with authentic materials (hands-on), surprise effects, novelty, knowledge acquisition, and social involvement, have been identified for upper grade students in connection with zoo visits (Dohn, 2013). The use of various methodological approaches (media and visual aids) proved to be especially useful in natural history museums for developing SI (Schmitt-Scheersoi & Vogt, 2005).

Research questions

With consideration for interest theory, the following questions arise with regard to the initial problem:

1. How should a teaching concept and the associated supporting materials for primary school teachers be designed in order to help them guide their students through a wildlife park in a way that sparks students' interest?
2. To what extent is situational interest in the wildlife park awakened by the use of this teaching concept and the supporting materials, and what factors play a role here?
3. Are the basic psychological needs, which underlie the self-determination theory, met by the use of the teaching concept and the supporting materials in the wildlife park?
4. How does this intervention influence students' interest in animals in general (topic-specific interest)?

Methodology

Due to its success in science education in recent years, the Design-Based Research (DBR) approach was used to generate findings on current educational research in addition to the contribution to teaching practice (Design-Based Research Collective, 2003; Knogler & Lewalter, 2013; Reinmann, 2005; Scheersoi & Hense, 2015). The goal of this research approach is not to perform lab studies under strictly controlled boundary conditions and then to determine the effects of individual factors using control groups, which would limit the effectiveness of the teaching approaches to be studied. Instead it aims to develop suitable learning environments based on evidence, with an awareness of the complex interplay between various influencing factors (Wilhelm & Hopf, 2014). Moreover, theory-based learning arrangements are subjected to a recurring (iterative), detailed review and redesign process that involves both education researchers and practitioners (often teachers).

Developing the teaching concept and materials

Based on observations of school classes during wildlife park visits, the preliminary studies first involved a detailed problem analysis with the participation of teachers and biology educators. Next, initial proposals were developed for the design of the student and teacher materials (design hypotheses). In addition to the assumptions of interest theory (Krapp, 1998, 2005) and self-determination theory (Deci & Ryan, 1993, 2002), these were based on findings from interest research studies in out-of-school learning sites (Dohn, 2013; Schmitt-Scheersoi & Vogt, 2005; Scheersoi & Tunnicliffe, 2014). Furthermore,

Animal species/station	Biological context	Visual aids	Hands-on material
Brown Bear	Locomotion	Bear paw (original)	Picture: 'pacing'
Otter	Adaption	Fur (original)	Hour glass
Wild Boar	Livestock, sensory organ: nose	Fur, natural bristle (originals)	Scent box
Feral Horse/ Bovine	Artiodactyl, Perissodactyl	Foot bones (original)	Rustling pairs
Red Deer	Reproduction, fitness	Parts of antler, antlers (original)	Jump rope
Lynx	Sensory organ: eye	Picture of pupil (picture)	'Lynx telescope'
Wolf	Predator teeth	Cranial (cast)	Maxillary and mandibular

Table 1: Materials used with the discovery cart.

the specialised biology content (wildlife biology) was analysed with consideration for the target group (primary-school students).

For the subsequent test of the design hypotheses as part of a formative evaluation, specific student and teacher materials regarding wildlife biology were developed (Table 1), and were evaluated beforehand by two students and one primary school teacher in terms of practical applicability, methodological fit and interest level (motivational effect). The materials were revised based on their responses; hence, additional visual aids were developed and the implementation instructions for teachers were expressed more specifically.

In the second evaluation step, the revised supporting materials were tested in the wildlife park, in a handcart prototype, by six teachers and their classes (2nd grade, average age of 7, N=96). Groups were observed by the investigator (participant observation) during their use of the materials. Simultaneously, the teachers' perspective was documented using a questionnaire and based on reflection meetings.

In addition to the positive aspects, the findings also identified the following problem areas:

- Timing problems: Some of the stations planned for individual animal species were too time-consuming. Student motivation could not always be maintained.
- Structural problems: The order of tasks turned out to be problematic for stations where animals were easily visible and active right from the beginning.
- Methodological problems: Some tasks were difficult to complete with a large number of participants.
- Problems with the instructions: Some teachers had trouble directly applying suggestions for using the materials without prior orientation.

Based on the prototype and input from teachers and wildlife park employees, the stations and tasks were adjusted in terms of their methodology, duration and the order of the tasks. Furthermore, they were supplemented with various implementation aids.

Figure 1: 'Discovery Cart': (a) side view, (b) view of opened compartments

The resulting revised development product is a handcart stocked with visual aids and hands-on materials (the Discovery Cart, see Figure 1). This enables teachers to independently guide their students through the wildlife park, with the help of the user instructions and even without any preparation.

Afterwards, the Discovery Cart underwent a final test through a summative evaluation with 23 school classes (N=339) (see Figure 2).

Survey tools

The study used both quantitative and qualitative survey methods. Besides reciprocal validation, this combination of quantitative and qualitative approaches helped determine the conditions under which situational interest is developed.

Quantitative testing instruments for the primary school children were developed alongside the Discovery Cart. First, the comprehensibility of the question and answer formats in the questionnaires was tested with individual students (N=2). Based on the study methodology of 'thinking out loud' (Sandmann, 2014), students were asked to state the questions in their own words and explain their answers. Confusing questions were changed accordingly. In the second step, the six classes (N=96) who visited the park with the prototype completed the questionnaires that had been revised after the first test round (see Figure 2). After calculating reliability (Cronbachs α; Tab. 2), the instruments were once again optimised and finally used in the main study (N=339) as summative evaluation instruments.

Table 2: Scales of student questionnaires

Instrument	Number of Items	Source	Example item	Reliabilities Cronbachs α		
				Pre-test	Post-test	Follow-up test
Situational Interest	8	Linnenbrink-Garcia *et al* (2010), Geyer (2008)	*'I find the discovery mobile very exciting'.*		0,79 (N=311)	
Basic Needs	5	Deci & Ryan (2002), Geyer (2008)	*'I felt comfortable with my teacher'.*		0,69 (N=310)	
Topic-specific Interest	5	Holstermann (2009)	*'Learning about animals is fun'.*	0,81 (N=306)	0,80 (N=310)	0,84 (N=291)

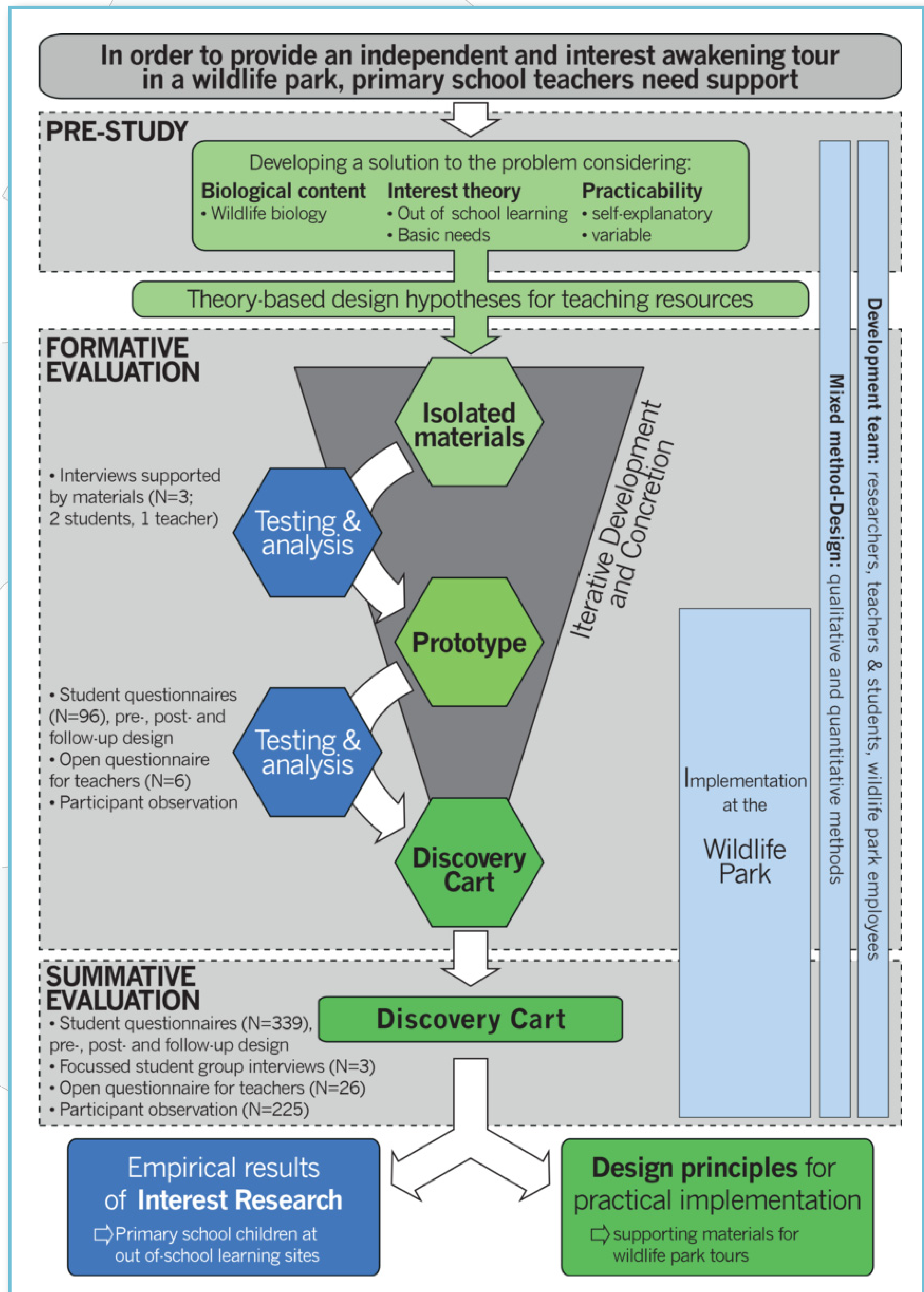


Figure 2: Procedure of study applying the DBR approach.

In order to document situational interest, eight items were formulated based on Linnenbrink-Garcia *et al* (2010) and Geyer (2008). Student evaluations used a five-point Likert scale (not at all true – hardly true – a little true – pretty true – very true; for an example, see Table 2 on p.19). Students' perceived motivation-relevant experience was recorded using self-developed items based on the self-determination theory of Deci & Ryan (2002), also following a five-step answer format (adapted from Geyer, 2008). The scale consists of one item on competency experience and two items each about relatedness and autonomy experience. Students' topic-specific interest in animals was recorded using 5 self-developed items (modified from Holstermann, 2009).

The preliminary tests were performed during regular instruction in school, about one week before the wildlife park visits. Post-tests took place immediately after an approximately 3-hour tour of the wildlife park with the Discovery Cart. The follow-up tests were performed 4-6 weeks after the wildlife park visit. In order to ensure implementation objectivity, the written questionnaires were introduced with standardised instructions and given by the same person for all three testing times (Bortz & Döring, 2009).

In addition to creating frequency tables with a calculation of the corresponding statistical parameters, Mann and Whitney's 'U Test' was used to check difference hypotheses for two independent random samples. The Wilcoxon Test was used to study dependent random samples at different testing times.

As part of the qualitative data collection methods, 13 classes (N=225) were studied through participant observation (Flick, 2007); three focused group interviews were conducted (Bortz & Döring, 2009); and 26 of the accompanying teachers were surveyed using a questionnaire consisting of open-ended and yes/no questions (see below).

Semi-standardised observation guidelines were created for the observations, and observable indicators (e.g. fun, curiosity) were formulated on the basis of interest theory in order to categorise the corresponding student activities (Bortz & Döring, 2009; Flick, 2007; Mayring, 2002).

The focus group interviews with students were performed immediately after wildlife park visits with the Discovery Cart. Additionally, they were transcribed and their content was analysed (Mayring, 2008; Gropengießer, 2008). Semi-standardised interview guidelines, which had been created based on interest theory (Mitchell, 1993; Krapp, 2002) and self-determination theory (Deci & Ryan, 2002), were used and served as a framework for data collection. Further, the guidelines provided enough flexibility to ask new questions based on the interview situation (semi-structured interview).

The teacher questionnaire was initially used to determine the practicality of the Discovery Cart concept and the implemented student and teacher materials. Additionally, teachers were asked about their perspective of the students' behaviour: they were asked to describe their students' behaviour and behavioural patterns, which they had observed during the tour, and to provide possible explanations for their occurrence.

Results and discussion

Teaching concept and supporting materials

The result of these studies is a teaching concept that allows primary school teachers to guide their students through a wildlife park and includes the following components:

1. A handcart, clearly divided into separate topics that can be taken on the tour, which offers plenty of hands-on and visual materials for an entire class for each animal species.
2. Self-explanatory, clearly comprehensible user instructions that allow teachers to use the supporting materials in the handcart flexibly according to the chronological, content-related and methodological conditions in each situation.
3. Teaching resources that contain the following components for each animal species found in the wildlife park:

    - Observation tasks for the species, which mainly focus on aspects that are new or less obvious to students. Search-based assignments and comparison tasks were shown to be particularly useful in sparking interest.

- Narrative elements including original visual materials, which students can touch and that provide additional information.
- Material-supported student activities related to the species that involve discovery and promote group experiences.

The practicability of the Discovery Cart was confirmed by all of the participating teachers and the wildlife park employees. Teachers said they felt *'well prepared'* and *'well-supplied with sufficient materials'* (Teacher #3). They said that their expectations were fulfilled in several ways, and particularly praised *'the openness of the resources. Options without "requirements". Being able to act depending on the situation, weather + children'* (Teacher #1). The Discovery Cart was found to be *'very structured and well thought out'* (Teacher #4), *'easy + customisable'* to use (Teacher #1) and the construction was *'sturdy'* (Teacher #7).

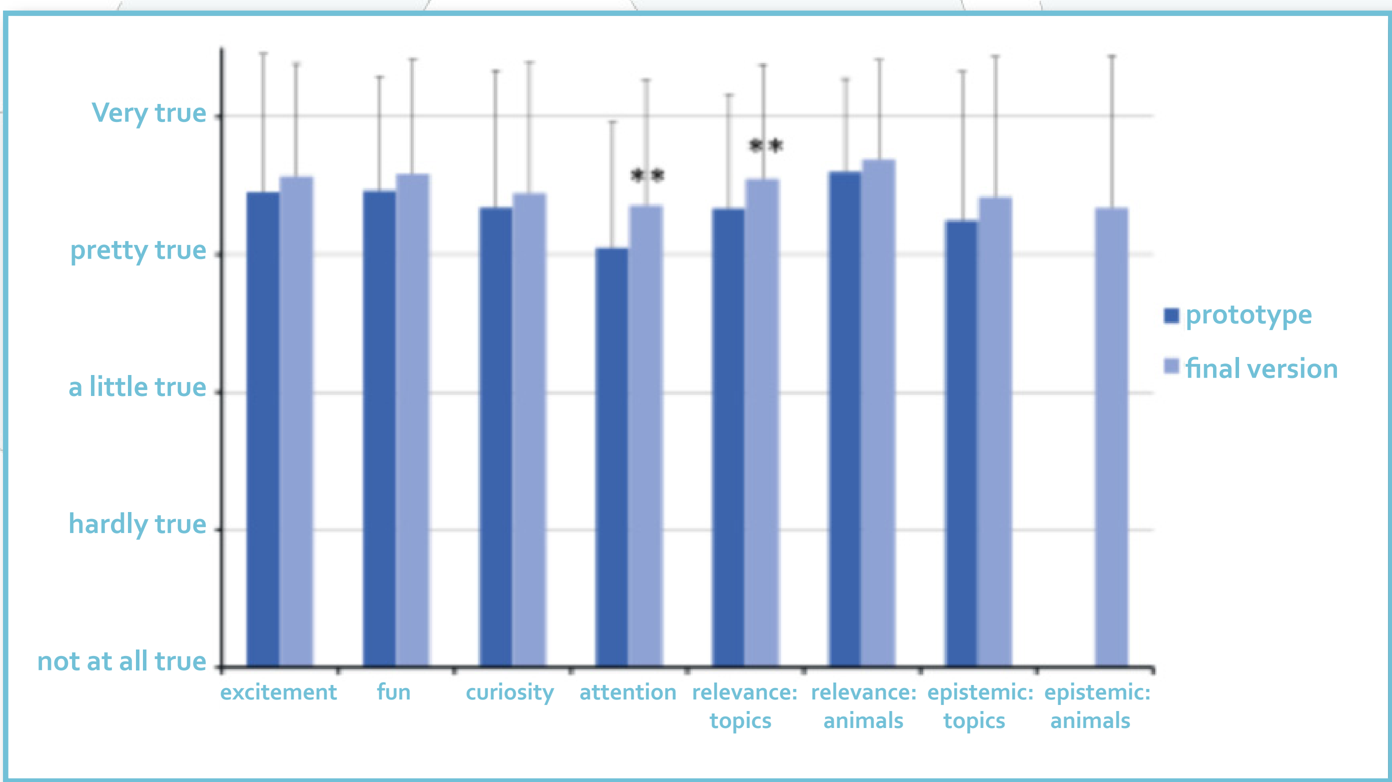
As additional proof of its usefulness, the wildlife park acquired the Discovery Cart in 2014. Since then, it has supplemented the park's learning materials and was used by approximately 20% of school tours in 2015.

Development of SI through the use of the Discovery Cart

With regard to the development of SI during the wildlife park visit, high mean scores were reported for all aspects, ranging from 4.34 to 4.69 (max value 5; see Figure 3). The highest values for SI came from the perceived level of 'fun' in working with the Discovery Cart (M=4.58; SD=.82; N=311) and its perceived 'relevance' for the animal species being studied (M=4.69; SD=.72; N=310).

Compared to the prototype, the revised final version of the Discovery Cart (see Figure 3) showed an increase in SI for all the surveyed areas. This applies in particular to the dimensions of 'attention' (Cohens d=0.43; p=0.001) and perceived 'topic relevance' (Cohens d=0.29; p=0.005). Because the item was changed in the course of reliability calculations, no comparison value has been determined for the prototype with regards to the epistemic component for the species being studied. The qualitative data support the quantitative results of the student survey. The research indicates that students in all the observed classes were consistently very interested in the materials provided by the Discovery Cart as

Figure 3: Emergence of situational interest during wildlife park tours with the Discovery Cart (mean values); N=74 (Prototype), N=312 (Final version), Significance level: *** p<0,001; ** p<0,01; * p<0,05 (Mann-Whitney). Missing data concerning the prototype due to change of items after calculation of reliability.



presented by the teachers. They were often enthusiastic about the individual stations and were very attentive and curious during the entire tour.

As reasons for the creation of interest, the factors identified by Dohn (2013) for upper grade students were also confirmed for primary-level students, from both a student and a teacher perspective:

- **Hands-on:**

'...they made you curious because you don't learn as much from looking as when you can try things out and really experience them' (Student, age 8).
'All of the hands-on stations were very motivational for the students' (Teacher #18).

- **Surprise/novelty:**

'because you...well, because you saw things there that you haven't really seen with the animals before' (Student, age 8).
'Lots of aha moments' (Teacher #18).

- **Knowledge acquisition:**

'Well, I thought it was really interesting because we learned a lot too' (Student, age 8).
'Added knowledge for teachers and students' (Teacher #5).

Likewise, it was confirmed that working with original objects and using a variety of methodological approaches (Schmitt-Scheersoi & Vogt, 2005) had a positive impact on the development of interest:

- **Original objects:**

'Because it was all real' (Student, age 8).
'...because the children knew they were real' (Teacher #5).

- **Various methodological approaches:**

'Well, it was all of it together, you know: first of all, the observations got you interested in the animal, and then you learned even more about the animal, and then you got to look at the skull too' (Student, age 9).

In the questionnaire, in addition to the initial SI (the 'Catch'), teachers also emphasised the longer period of attention (the 'Hold') for the topics covered by the Discovery Cart:

- SI Catch: *'All of the children are very interested and are having a lot of fun'* (Teacher #13).
- SI Hold: *'The Discovery Cart was able to capture and focus their attention for a lengthy period of time'* (Teacher #18).

Motivation-relevant experiences during tours with the Discovery Cart

With regard to the motivation-relevant experience, the experience of relatedness and autonomy was recorded along with the competence experience (basic needs). For social integration, a distinction was made between integration with the teachers (T) and with other students (S). In the area of autonomy experience, the two facets of 'self-determination' (sd) and 'fits with personal wishes and goals' (PWG) were defined.

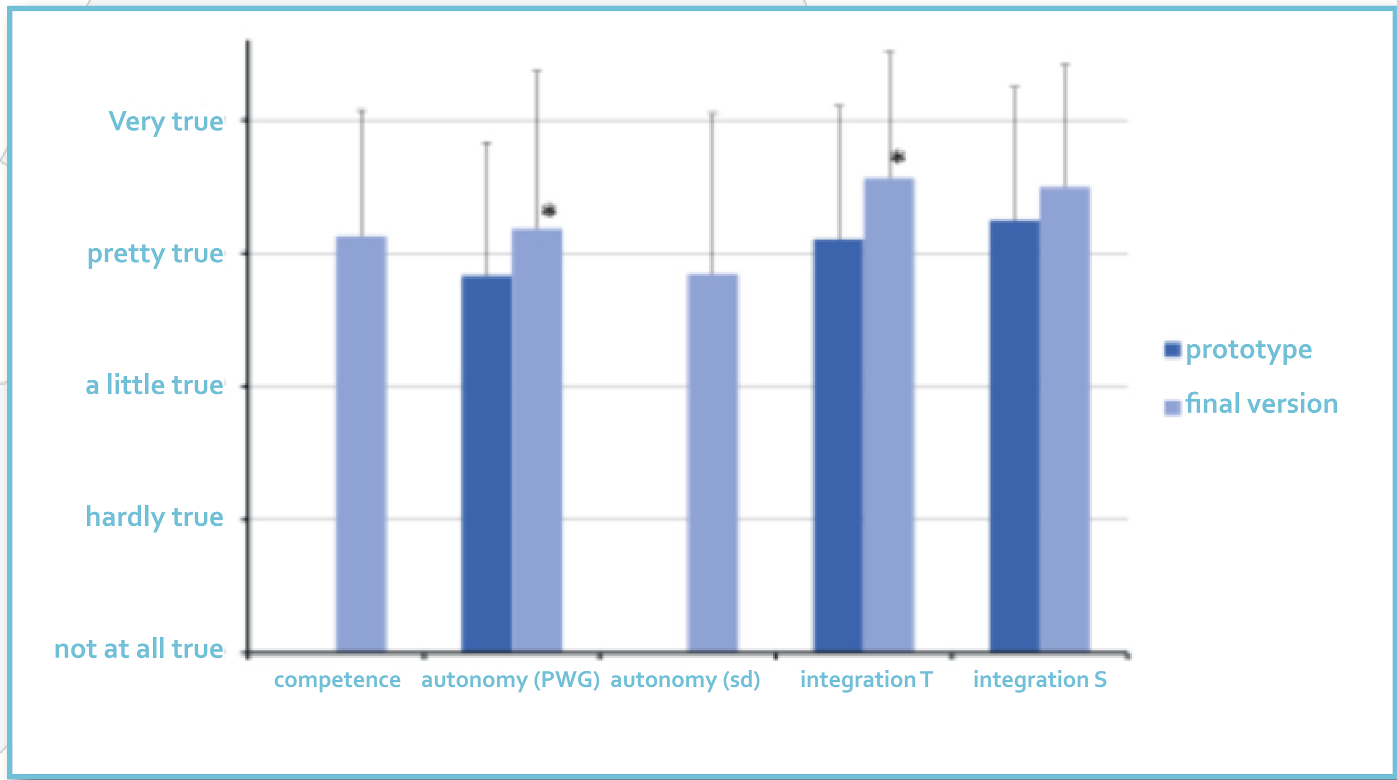
The mean scores for social integration with teachers (M=4.56; SD=.95; N=312) and with students (M=4.50; SD=.92; N=313) were especially high.

Equally high values were determined for the competence experience (M=4.13; SD=.94; N=309). The experience of autonomy in the area of sd, with a mean score of 3.84 (SD=1.12; N=308), was the lowest of all the values, while the autonomy experience for PWG achieved a high value, comparable to the competence experience (M=4.18; SD=1.18; N=309). Clearly, the students' personal wishes are strongly aligned with the situation-specific requirements for the individual stations, while the autonomy experience is much less pronounced in terms of their efforts to act in a self-determined way (Figure 4).

Compared to the prototype of the Discovery Cart, the final version showed an increase in motivational experience in every area, in particular regarding the PWG component of the autonomy experience (Cohens d=0.31; p=0.019), as well as social integration with the teachers (Cohens d=0.39; p=0.004). No comparative values were calculated for the prototype in the area of competence experience and autonomy sd, due to a lack of equivalent items after the scale was revised.

The quantitative data about the motivation-relevant experience were largely supported by the qualitative data. It was observed that students

Figure 4: Motivation-relevant experience (basic needs) during the tours with the Discovery Cart: N=79 (prototype), N=310 (final version). Significance level: *** p<0,001; ** p<0,01; * p<0,05). Missing data concerning the prototype due to change of items after calculation of reliability.



were able to handle the wide range of requirements at the various stations very well. Students confirmed the appropriate difficulty level of the tasks in interviews. For their part, teachers confirmed the target-group-appropriate performance level:
'There were [...] enough breaks so that they could rest. They weren't overwhelmed' (Teacher #6).

At the same time, it was especially emphasised that even shy or weaker students were able to participate successfully in the offerings:
'Weaker students made great observations' (Teacher #4).
'Even students who are quiet in class participated' (Teacher #20).

With regard to the second facet of the autonomy experience (self-determination), it was found that many students conducted their own freely chosen animal observations in addition to the assigned tasks, and that they often studied and used the materials according to their own ideas. Students also independently varied the tasks and largely chose the social format themselves. The working tempo varied depending on the student and the group composition.

The interviewed students approved of the balanced and appropriate relationship between guided instruction and free activity. They made sophisticated comments both on the need for instructional tasks that limit autonomy and the benefits of independent activities and decision-making:
'...I did think it was good, what you told us to do... you just said it out loud, but we still learned something and got to try it out for ourselves' (Student, age 9).
'But if you just get everything, just have it thrown at you, you also don't know what you're supposed to do or what you're learning from it' (Student, age 8).

In terms of social integration, the qualitative data support the results of the student questionnaires as well. During the Discovery Cart tour, there were hardly any disagreements between individual students. The children often pointed out interesting aspects of the stations to one another, helped each other work on the tasks, and shared the materials.

The students confirmed the positive class environment during the interviews. To some extent, this was explained by their shared interest in the stations:

'Well, I felt comfortable because, well, if I had gone by myself it wouldn't have been like that, but in the group, okay, because then you talk to the other students about it: look at the eye, I just saw something, and so on' (Student, age 8).

Teachers described the students' behaviour as balanced, even for difficult learning groups during the tour:

'The children hardly fought at all. They were cheerful and well adjusted' (Teacher #6).
'A great willingness – even among disruptive children – to listen, to be curious, to absorb knowledge, to try things out and experiment' (Teacher #22).

Development of topic-specific interest

The students' interest in animal-related topics was studied at all three testing points. Five facets were defined, each represented by one item: fun in learning, object-based interest, meaningfulness of the task, frequency of activity, and significance of thinking about animals (for a sample item, see Table 2).

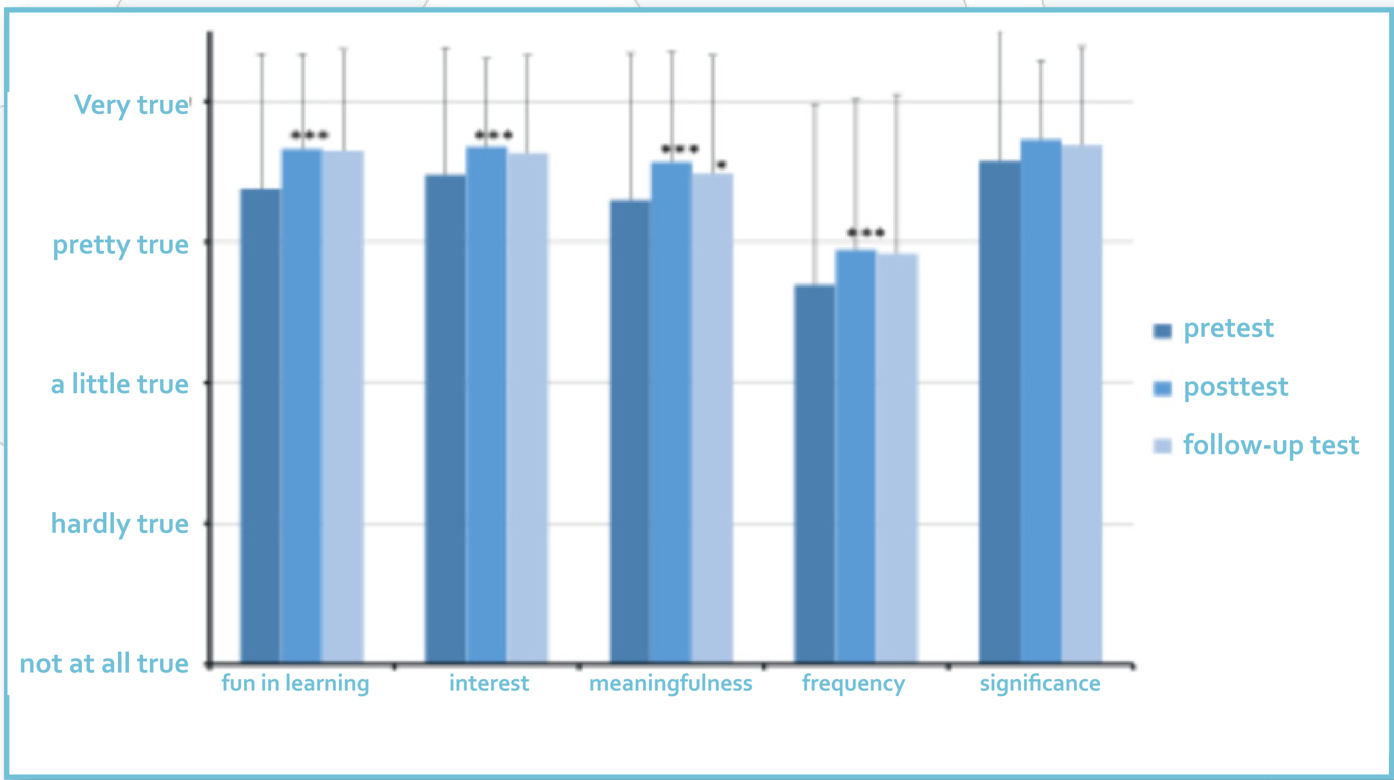
An isolated consideration of the preliminary test showed high and closely aligned mean scores between 4.30 and 4.58 (Figure 5), with the exception of the item *frequency* proving to be an outlier (M=3.7; SD=1.29; N=306). If the post-test performed immediately after the wildlife park visit is used as a comparison, interest in the topic increases significantly in all the areas except significance (0.20<Cohens d<0.34; p<0.001).

From the post-test to the follow-up, the mean scores for all aspects were nearly unchanged, except for the significance of thinking about animals. The slight decrease in this value is only mildly significant (Cohens d=0.09; p=0.012). If the preliminary and follow-up tests are compared, the mean scores for the first four components of the topic-specific interest are still significantly higher.

Summary

In order to allow primary school teachers to lead their own tours in a wildlife park, the DBR approach was used to develop a practical teaching concept and corresponding supporting materials (the 'Discovery Cart'). In addition to incorporating original items and using various methodological approaches, design principles also included the surprise effects, hands-on materials and the promotion of social interactions mentioned by Dohn (2013) for upper grade students.

Figure 5: Topic-specific interest in animals (N=302): significance level: *** p<0,001; ** p<0,01; * p<0,05 (Wilcoxon).



During the tour with the Discovery Cart, students were observed to have strong levels of situational interest and motivation-relevant experience, which further improved in the course of the development process and the subsequent studies. The preliminary studies showed that children rarely thought about the often-distant animals beyond a non-specific observation. Thus it can be assumed that the determined effects are due to the Discovery Cart.

Furthermore, the findings show that the students' general interest in animals was increased by the intervention.

The limits of the study result from the quasi-experimental study design, which allows for alternative explanations of the determined effects. Disruptive effects from the different teachers cannot be ruled out. Nonetheless, the methodological approach proved suitable for developing theory-based materials for direct teaching practice and for deriving corresponding design principles and making statements about interest research for primary school children.

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Scientific enquiry and engaging primary-aged children in science lessons Part 2: why teach science via enquiry?

● Amanda McCrory

Abstract

The first part of this article, published in the summer 2017 issue, JES 13, discussed and reflected on the concept of scientific enquiry in primary schools, including the possible barriers to provision of the primary science curriculum via enquiry. The second part of this paper firstly discusses the positives of teaching scientific concepts via enquiry, before presenting two case studies centred around children in Year 5 (age 9-10 years) and Year 6 (age 10-11 years) learning science via enquiry. The case studies specifically focus on the nature of science using authentic, meaningful learning opportunities and cross-curricular aims.

Keywords: Controversial issues, engagement, enquiry, observation, Ofsted, PCK (pedagogical content knowledge), nature of science, questioning, process skills, scientific concepts, socio-scientific issues, working scientifically.

Practical work in science lessons – why teach via enquiry?

Engagement and motivation…

Amanda Spielman, the current Chief Inspector of Ofsted, recently questioned the usefulness of practical science experiments when addressing the audience at the 2018 ASE Annual Conference (2018). Her concern lies with the outcomes of a survey published in John Holman's Gatsby report (2017) on 'Good Practical Science', which argues that secondary school teachers rate motivation as the most important factor in teaching science practically. Granted, her speech in the main focused on enquiry in secondary schools; however, the parallels to teaching science via enquiry in primary schools are clear. Spielman argues that we should be uncomfortable with the idea of practical science being mainly about motivation. The important word here is *mainly;* it is no secret that declining student engagement in both secondary and primary science has been a source of angst for scientists and science educators for some time (Ofsted, 2011) – no wonder then that motivation and engagement are high on the agenda. Good science teachers know that motivation is key to engaging children in learning science, so that teachers can then actually teach! Quite frankly, as any teacher knows, it is very hard to teach a child anything when s/he is disengaged; therefore, motivation and a positive attitude to science is an important first step to engaging with learning science.

Evidence from the field of neuroscience supports the argument that the first stage in learning is motivation (Collins, 2015); persistence is a required state for most learning – children need to practise, repeat, try again and practise. In addition, exploration and investigation increase creativity and brain plasticity, which help children to become open to new ideas and be more creative in their own ideas (Collins, 2015), all strong arguments for teaching science via enquiry. Therefore, is this argument simply about 'motivation' and 'science taught practically', or perhaps a fundamental misunderstanding by some, including class teachers, regarding the role of scientific enquiry in enhancing scientific knowledge and understanding and the pivotal role teachers play in this?

The link between being curious and creative, and scientific endeavour – the importance of children making sense of the world around them via exploration

Maintaining curiosity is an important aspect of science education; scientific enquiry is *'crucial in developing and sustaining curiosity'* (Smith, 2016: 6). As we know, facilitating and promoting curiosity in science education is integral to the primary science curriculum (Ofsted, 2013); being curious and creative is vital to scientific endeavour:

'If you're doing an experiment on cells, and you want to find out why those cells keep dying, you have a problem. It really takes a level of creative thought to solve that problem' (Robert deHaan, cell biologist, cited by Cutraro, 2012).

Spielman (2018) also noted that children need knowledge and understanding before they can create and test hypotheses; it would have been fruitful for her to elaborate on this further, because young children's ideas develop from interaction with the physical world around them – learning is cyclical, not linear. In early years and primary science, children make observations and hypotheses all the time and this starts at a very young age: *'Babies formulate theories, make and test predictions, seek explanations, do experiments and revise what they know in light of new evidence'* (Gopnik *et al*, 2001: 161). Toddlers build on their early experiences and become intrigued by finding out what things can do and how things can be changed. All this early experience leads to pre-school children with the attitudes, dispositions and skills to explore and investigate independently (Brunton & Thornton, 2010).

Children's alternative ideas or misconceptions

As children move into the early years foundation stage (EYFS) and then Key Stage 1 (age 5-7), these ideas can sometimes conflict with the recognised conceptual ideas of science as stated in the curriculum. Scientific enquiry therefore enables teachers to gauge an understanding of children's alternative ideas or misconceptions, so that teachers can provide opportunities to reconstruct children's scientific understanding (Allen, 2014). The importance of using alternative ideas as a starting point to develop children's scientific ideas, knowledge and understanding is clearly recognised (Harlen & Qualter, 2014).

Active processing includes relating new experiences and learning to previous experiences and real life events and this is an important part of the brain-based approach to learning, which includes situated learning, authentic contexts, the importance of prior learning, and engagement (Collins, 2015). This is closely related to 'mental processing' as described by constructionist theorists (Piaget, 1929; Bruner, 1966; Vygotsky, 1978): the notion that all new learning builds upon a foundation of what has gone before with the relating of new information to old being just as important.

Conceptual understanding and the role of enquiry

Therefore, curiosity and imagination should stimulate questions, predictions and hypotheses; it is then the teacher's role to enable children to explore ways to investigate and test out their ideas by making observations, gathering data, presenting their findings and then explaining what they have found out scientifically. This can only be achieved by teaching children how to analyse their data with an important learning aim of teaching children concepts that are new to them in science or, indeed, consolidating their understanding of conceptual science. Spielman (2018) also highlights this point. Giving children time to then evaluate what they have done often creates new questions and ideas to investigate further. Working scientifically is therefore *'crucial to facilitate conceptual understanding'* for all children (Smith, 2016: 6). It promotes inclusion as children work collaboratively, socially constructing their understanding of science; this enables the teacher to not only meet the needs of all children but also to provide opportunities to challenge them. Collins (2015) argues that complex learning is enhanced by challenge – scientific enquiry provides opportunities for teachers to facilitate this.

The nature of science

As I argued in Part 1 of this article (McCrory, 2017), there is now an increased focus on children understanding the nature of science; teachers need to be clear about what this is and how to teach it. For primary science teachers, this involves understanding that:

- there is not one scientific method that fits all, but many methodologies to pursuing knowledge in science; scientists are creative, and a one-size-fits-all scientific method can only be restrictive;
- scientific knowledge is tentative; although often supported by a wealth of data from repeated trials, it is not considered the final word – findings are tested and challenged. *This is an important part of the nature of science,* which can sometimes be neglected;

- scientific theories are underpinned by evidence (gathered via observation and experimentation); theories are not simply a guess, or ideas that have not been validated;
- observations and inferences play different roles in the development of scientific knowledge; and
- human error is inevitable – scientists are humans and make mistakes; pupils need to understand that critically examining mistakes or unexpected results is an important part of the process of enquiry.

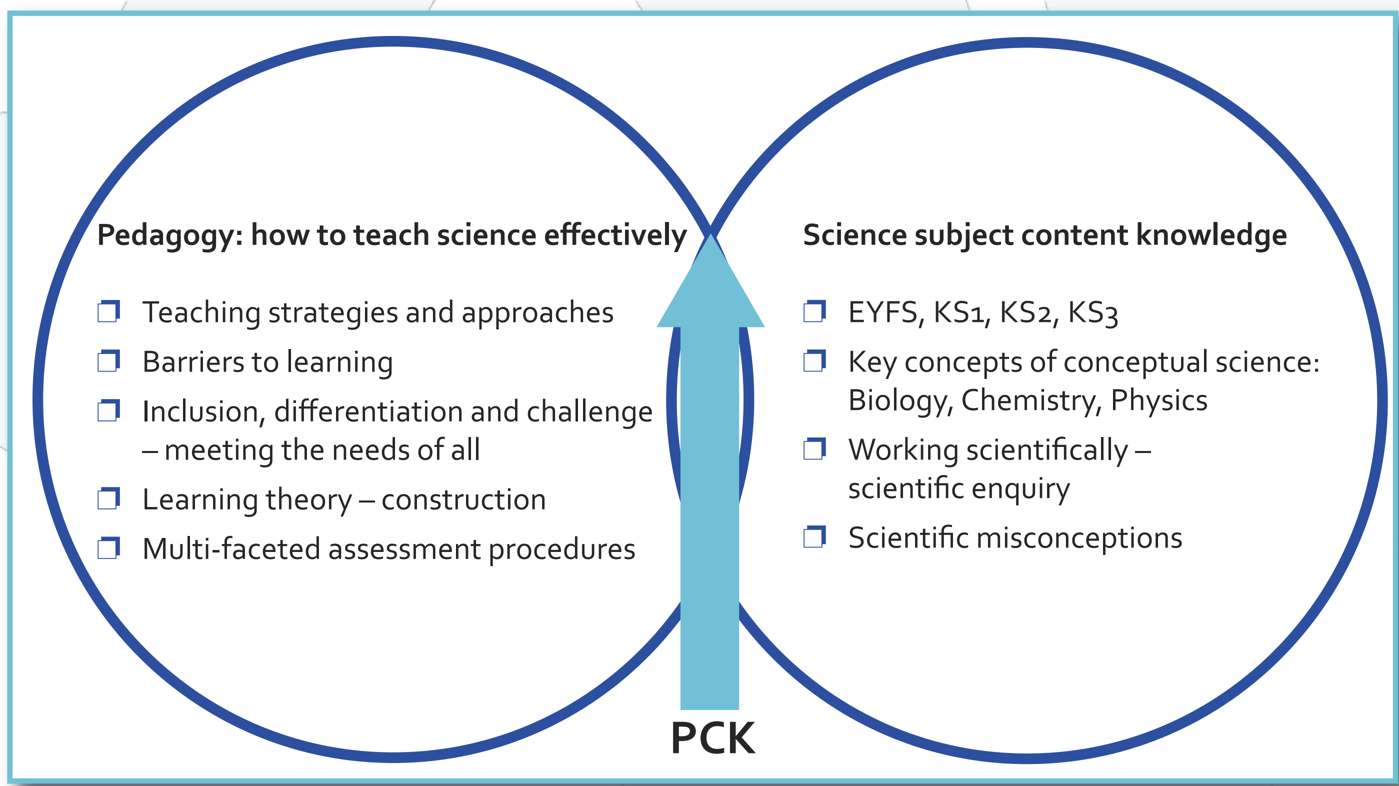
The teacher's role and pedagogical content knowledge (PCK) (Shulman, 1986)

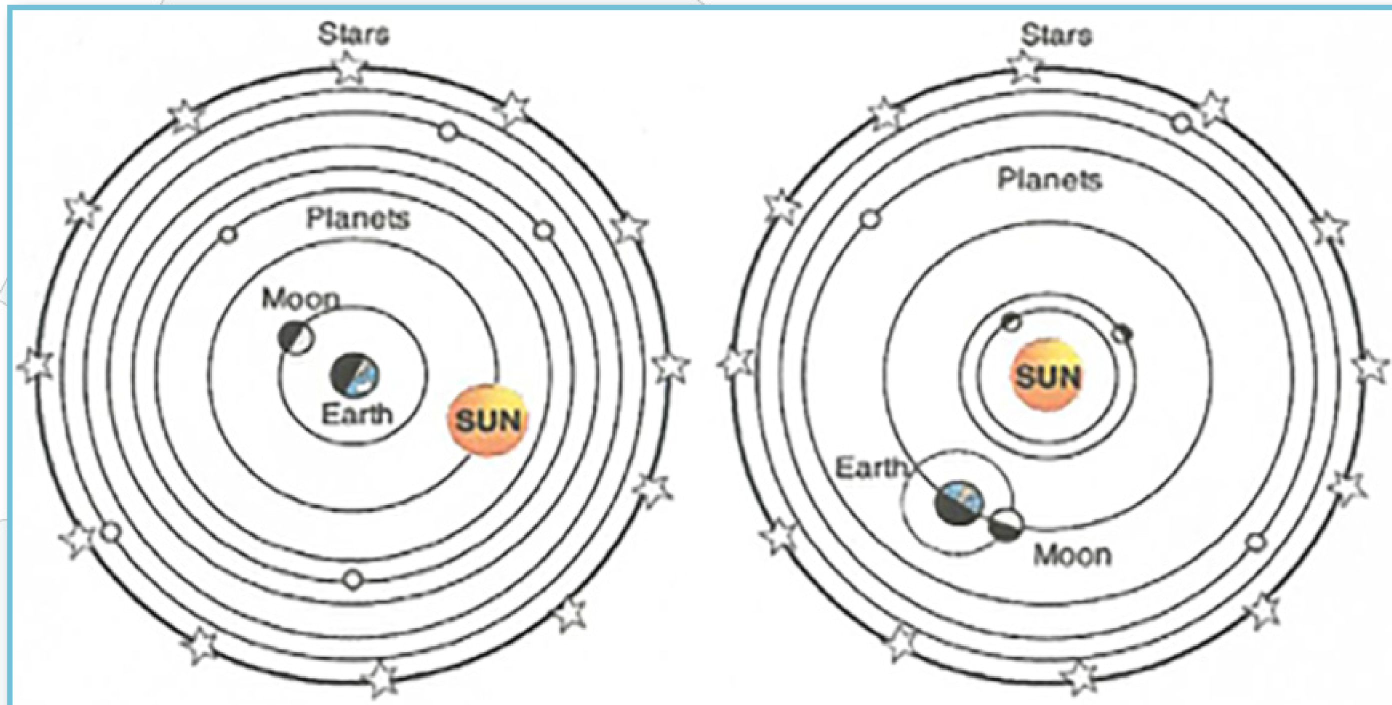
Unsurprisingly, it is the role of the teacher that is therefore crucial to delivering high quality science provision. It is a fundamental misunderstanding of teaching pedagogy in primary science to suggest that the teacher plays little or no role when children are working scientifically, or indeed that exploration or enquiry is simply about children having fun! On the contrary, the teacher plays a pivotal role when teaching scientific enquiry, to teach the skills involved as well as the scientific concepts.

This is an *'active process [by the teacher] which requires an organised approach'* (Smith, 2016: 7). Hattie and Yates's (2013) work on visible learning demonstrates how critical, and quantifiably so, a teacher's pedagogical content knowledge is to pupil success in learning. Pedagogical Content Knowledge (PCK) (Shulman, 1986) underpins effective teaching because it combines:

- multi-faceted knowledge (child development, learning theories, teaching strategies including explanations and demonstrations, which make abstract principles concrete for children to understand; inclusion and differentiation – understanding barriers to learning and how to overcome them) that the teacher has of ***how to teach*** a subject, so that children progress in their knowledge, understanding and skills (which informs the cycle of planning, teaching, marking and assessment); with
- a deep knowledge of the curriculum subject content (the national curriculum, the nature of science, key concepts within science subject knowledge, scientific enquiry skills, and scientific misconceptions or children's alternative ideas).

Figure 1: PCK (Pedagogical Content Knowledge) for teaching science in primary schools (McCrory & Worthington, 2018).





Geocentric Theory **Heliocentric Theory**

Use your **research skills** to find out what you can about each model
Can you **explain** the differences between the two models?
How was **scientific evidence** used to support each model?
Use **scientific language** in your work!
What do you need to find out more about?

Figure 2: The stimulus given to Year 5 children to research and investigate the geocentric and heliocentric models (McCrory & Worthington, 2018).

The case studies included here demonstrate cross-curricular ways to teach children science concepts whilst working scientifically, with a particular focus on the nature of science and authenticity in learning about science concepts.

Case Study One: Year 5 children (age 9-10 years) learning about the nature of science via working scientifically

When learning about Earth and Space in Key Stage 2 (age 7-11), non-statutory guidance suggests that pupils should find out about how ideas about the solar system have developed over time, by understanding why the geocentric model of the solar system was replaced by the heliocentric model through considering the work of Ptolemy, Copernicus and Galileo. Figure 2 was presented to a class of Year 5 children as a stimulus to use their enquiry skills to understand more about this. The pupils were also asked to consider what scientific evidence was used to support the claims of each model. The outcomes of one child's work is demonstrated in Figure 3.

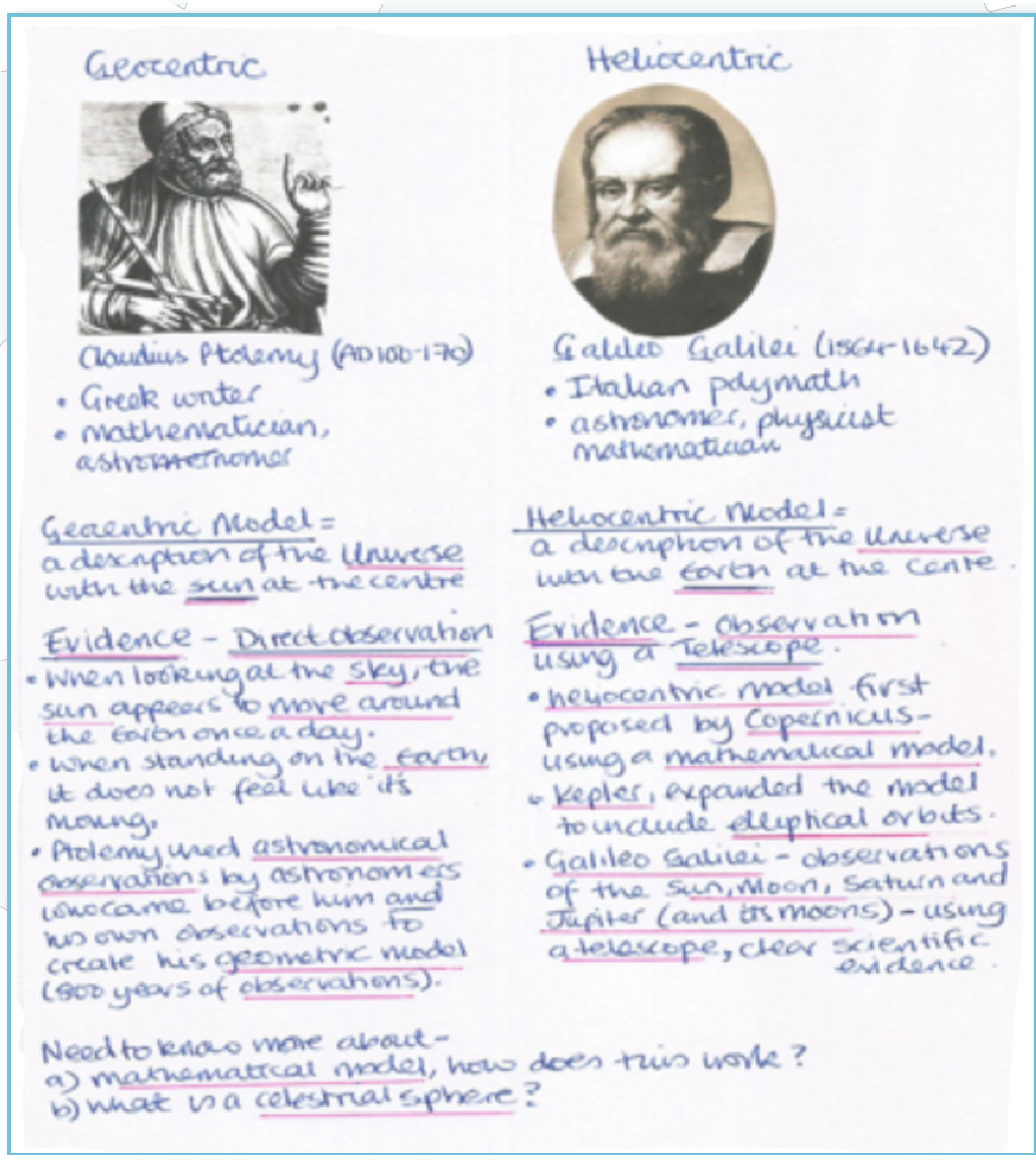
What was the role of the teacher here?

The teacher orientates the children by almost providing success criteria (although not referred to as such) that are clear for the children to understand (Nottingham & Nottingham, 2017). It can be argued that there is shared understanding between the teacher and the children (this does not simply happen by itself but is facilitated, over time, by the expectations of the class teacher); the phrases *research skills, scientific evidence, explain* and *scientific language* are highlighted but not explained, indicating that the teacher is building on what he knows the children already know

(Hattie & Yates, 2013). The outcomes of the lesson, as exemplified by one child's work in Figure 3, support this assessment. It can be clearly seen that the child has highlighted the scientific vocabulary used and included everything required of the task. What is not clear is whether or not the teacher has prompted the child to do this. I have no doubt that some children would need this prompt; however, it might very well be that what was once an explicit expectation directed by the teacher has now become implicit for the child in question.

The teacher has chosen resources that he thinks the children can access based on his knowledge of the children (PCK, Shulman, 1986). When introducing this, the teacher did not simply give the

Figure 3: An example of a Year 5 child's response to the challenge in Figure 2 (McCrory & Worthington, 2018).



children the diagram and tell them to get on with the research. On the contrary, he was careful to ask the children to explain their initial understanding of the difference between the two models by asking the following questions:

1. We have been learning about the Earth, Moon and Sun. Let's recap what we know about these.
2. We have also been thinking about how scientific knowledge changes over time because of evidence. What are these two models demonstrating?
3. Can you see any similarities?
4. Can you see any differences?

The teacher encourages the children to recap what they have learned so far, so that they can make connections between what they know and what they are about to analyse and learn (Hattie & Yates, 2013). The aim here for the teacher is to facilitate the children learning for themselves, to encourage independence and resilience. In terms of working scientifically, this lesson gives the children an opportunity to identify scientific evidence that has been used to support or refute ideas in science (DfE, 2013), whilst using their process skills to answer questions so that they can deepen their understanding of the two models. Through activities such as this, children's thinking, reasoning and questioning skills are nurtured (ASE, 2017).

Reflections

- It is clear that the teacher has taken a cross-curricular approach to teaching science, with links to English and history. The child has found out about the scientists who created the models and provided some short biographical information – the child has communicated the results of his/her enquiry effectively, demonstrating that s/he has not simply copied information from the Internet or an information book.

- The child has identified the different types of observation (direct, and the use of a telescope) used as evidence to inform the models. Interestingly, the child gives examples of direct observation that s/he can relate to. What is not clear in this example is how the child has evaluated the evidence for each model (although s/he does note that the use of the telescope is clear scientific evidence) and, therefore, does not indicate clearly if s/he understands why the heliocentric replaced the geocentric model. Therefore, a next step from this lesson would be for the child to explain this clearly.

Case Study Two – using controversial issues to engage children in learning science

Controversial issues in contemporary life are issues about which there might very well be social disagreement (different individuals and groups interpreting and understanding in differing ways), competition or conflict, but are not easy to define (Sadler *et al*, 2016; Woolley, 2010). It is crucial to understand that a '*controversial issue must involve value judgements, so that the issue cannot be simply settled by facts, evidence or experiment alone*' (Wellington, 1986: 3). Socio-scientific issues typically include a controversial aspect; they involve values and require *ethical reasoning* (Levinson & Reiss, 2003).

As argued earlier, pupil motivation is key to learning; engagement in contemporary issues (socio-scientific issues) is one way to stimulate interest in science (Sadler, 2011; Claire & Holden, 2007). If the social and ethical aspects of science were included more fully in school science, then many pupils may be encouraged to study science longer, as the humanistic side of science appeals to many pupils, particularly girls (Sadler *et al*, 2016). As we know, when taught well, children start to develop a love for science in the primary school, which can only happen if primary-aged children experience inspiring science that '*builds their understanding of the value and place of science in their lives*' (Wellcome Trust, 2013: 4).

Guidance for the National Curriculum also states that the social and economic implications of science are taught most appropriately within the wider school curriculum: clearly a recognition of the strength of primary teaching (taking a cross-curricular approach to teaching and learning). It also actively encourages creativity: '*teachers will wish to use different contexts to maximise their pupils' engagement with and motivation to study science*' (DfE, 2013: 3), which Wyse and Dowson (2009) argue '*is a right not a privilege*'.

This gives primary schools the freedom to deliver the curriculum in ways that they see best, as long as the statutory requirements are adhered to and children are given both the opportunities and time to develop their enquiry skills and conceptual understanding (ASE, 2017). The following example is the outcome of a project undertaken by two children in a Year 6 (age 10-11) class. The project is authentic and driven by the children's interests; in this case, the children were galvanised by the media story of a trainer at SeaWorld in Orlando who was killed by Tilikum, a killer whale kept in captivity. The report produced incorporated aims from computing, English, geography, maths, PSHE and science.

Final considerations and discussion

This article deliberately focuses on including two examples of working scientifically that are research-based and which require children to evaluate evidence as exemplars of how scientific enquiry does not always need to focus on 'fair testing' or 'experiments', although both of these quite rightly have a place in primary science

Figure 4 (part 1): An example of how to incorporate controversial issues in teaching science – is it right to keep killer whales in captivity? Paired work by two Year 6 children using scientific enquiry skills, ICT, reasoning based on scientific evidence and moral considerations. In addition, the children have demonstrated their scientific knowledge and understanding of science via representations: in this case, habitats, animal behaviour and diet, which are all communicated in a clear and engaging way to support their arguments alongside mathematical reasoning.

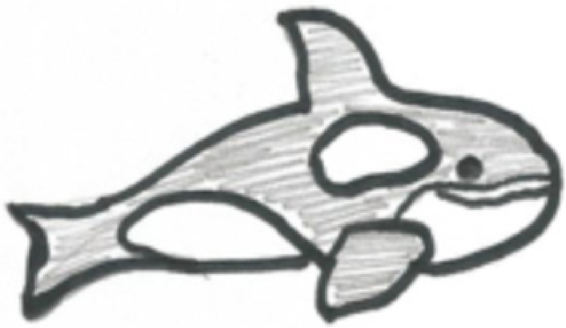
It is rare for an orca in the wild to have a collapsed dorsal fin, if this is the case, the reason is because the fin has been injured or damaged. In the wild, orca dorsal fins look like this: 	In captivity, orcas spend most of their time on the surface of the water – because of gravity, a lack of support from the water, and being fed an unnatural diet, orca dorsal fins look like this: 
Orcas live longer in the wild! In the wild, average life span for male orcas is 30 (max 50-60 years) ; female 46 (max 80-90 years).	In captivity, the average life span for male orcas is 17 and 27 for females.

Figure 4 (part 2):

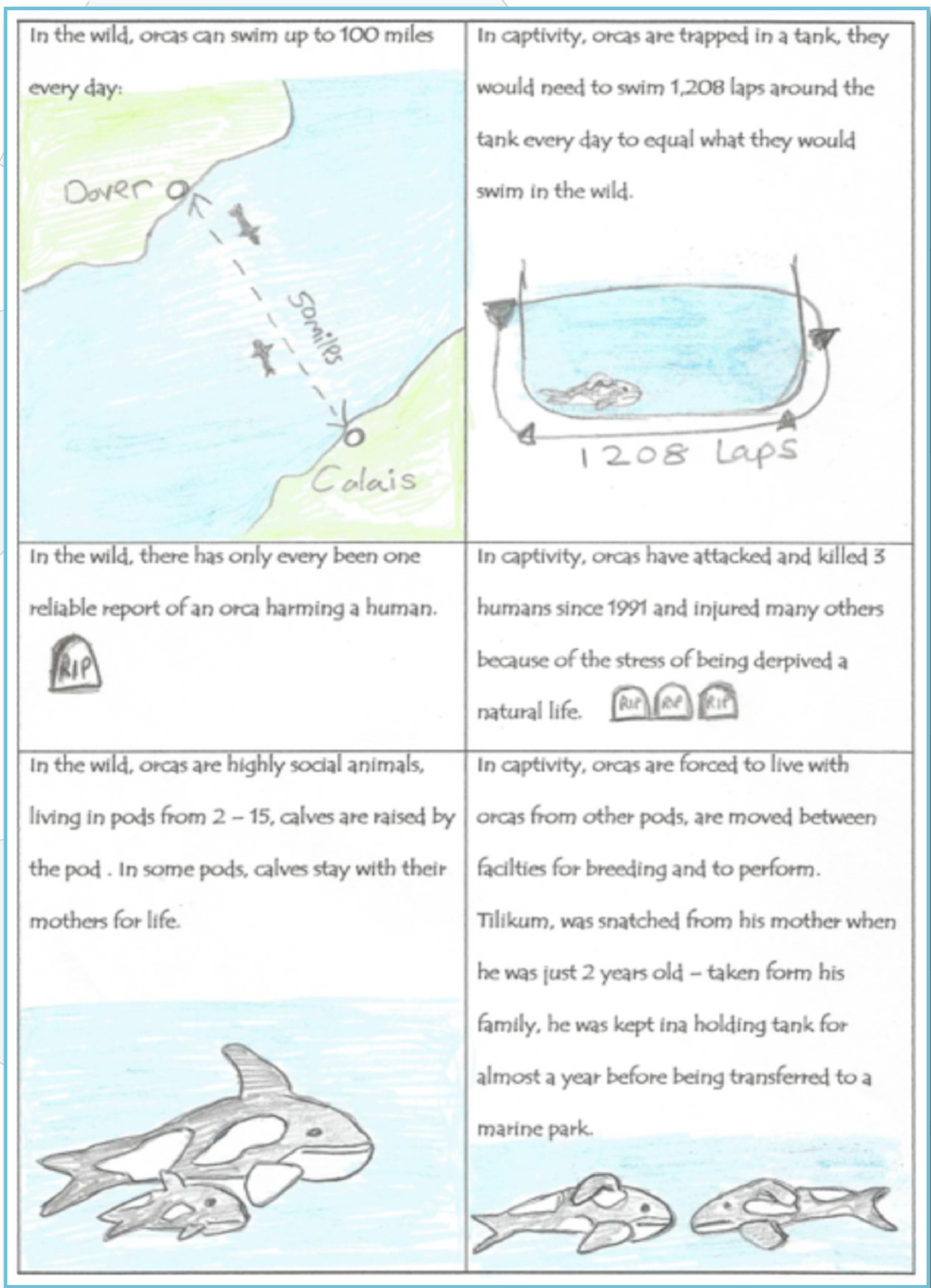


Figure 4 (part 3):

Is it right to keep killer whales in captivity?

We think that it is very wrong to keep killer whales in captivity because ...

'They are kept from their natural habitat, their dorsal fins collapse'

'They are kept away from their families, this is awful – this makes them very unhappy'

'They don't live as long'

'They become stressed and aggressive by being trapped'

'Isn't it wicked to keep them in such a small space when they are used to swimming for miles in oceans, they gnaw on the iron bars and concrete from being so stressed – this shows how much they want to escape, so would we if we were trapped and taken away from our family'

'They are fed an unnatural diet – they are unable to hunt or obtain water from their prey'

'Being in captivity is the same as being in prison but they have done nothing wrong'

'They are not for our entertainment'

education. Both examples focus on the *nature of science* and are provided to give teachers ideas of what can be achieved by teaching science via enquiry and in a cross-curricular fashion. In particular, when considering using socio-scientific issues to engage children in learning science, it is important for teachers and children taking part to understand the nature of the controversy – why, and in what way, is this topic controversial and how does it relate to science (Oulton, Dillon & Grace, 2004)?

Debate and discussion are key aspects of lessons based in controversial or socio-scientific issues and ground rules need to be agreed for group work and debates (an important aspect of this is using scientific evidence to justify arguments, as well as being able to identify evidence that is irrelevant); as with any form of discussion and debate, children need to be aware of the learning objective and their steps to success to meet the learning outcomes.

As one would expect, teachers should consider the cognitive capabilities of the children whom they are teaching in relation to the learning of the conceptual science. Pupils should be encouraged to express their own views in a safe environment, where they know that their ***views are valued.*** Children should be taught to appreciate the process, to take part in debate and discussion using scientific evidence (from a variety of sources) and language to support or refute arguments (engaging in the nature of science).

Teaching strategies are varied and can include: group work or paired work, role play such as 'decision alley' or theatre, ICT, debates, producing information posters, PowerPoint presentations, assemblies and research activities (which incorporate a whole range of scientific enquiry skills); this also provides a wealth of cross-curricular links integral to primary education and beyond. Using a variety of teaching strategies also serves to ensure that children do not become bored with the work that they are undertaking, allowing them to be creative and express themselves in many different ways (Wyse & Dowson, 2009).

Teachers should provide opportunities for children to consider the local, national or global implications of the issue and, where appropriate, build on the interests of the child (Duschl *et al*, 2007) – children may be made aware of controversial or socio-scientific issues via the media, movies, television and books and these can be a great starting point. However, teachers should provide children with opportunities to consider authentic controversial or socio-scientific issues that come from the children themselves, as in Figure 4, but which also enable the children to improve or consolidate their conceptual understanding of science concepts (Sadler *et al*, 2016; Spielman, 2018).

Another way to achieve this is through field trips, which typically have a favourable impact not only on enhancing the children's learning, but also by further capturing their attention, therefore adding to the authenticity of what the children are learning. Evagarou (2008) found that a field trip – in this case a visit to a local pig farm by children aged 10-11 – had a positive impact on the students' motivation in engaging with socio-scientific issues and furthering their understanding of the underlying scientific concepts. It provided an opportunity for meaningful learning.

There is now much more support for primary classroom practitioners in using these pedagogical approaches in their classroom; for example, the overarching aim of the PARRISE project (www.parrise.eu) is to share and improve best practices by integrating the pedagogical approaches discussed here – inquiry-based science education (IBSE) and learning based on controversial and socio-scientific issues. The researchers call their innovative approach 'Socio-Scientific Inquiry-Based Learning' (SSIBL), which scaffolds pedagogy so that teachers can build confidence together as they develop the skills needed to teach science in this way. The Primary Science Teaching Trust (PSTT) and the Association of Science Education (ASE) both provide primary teachers with teaching resources and opportunities for continuing professional development (CPD) to teach scientific concepts via scientific enquiry (ASE, 2017).

In conclusion

We can therefore surmise that delivering the science curriculum through working scientifically enables the early years and primary classroom teacher to:

- actively engage children in their learning via constructivism (Skamp & Preston, 2015);
- gauge an understanding of children's ideas about the world (Allen, 2014) and plan learning opportunities to build on these, as well as reconstruct knowledge and understanding;
- facilitate progress in conceptual knowledge and understanding of science via multiple teaching pedagogies (Shulman, 1986);
- challenge and include all children (Collins, 2015);
- encourage children to be curious and creative, because science is a never-ending journey of discovery by the curious (Ofsted, 2013);
- promote science as enjoyable in order to maintain a positive attitude to science. Motivation plays an important role in this (CBI, 2014);
- help children to understand the nature of science by examining evidence and using this to evaluate science concepts and ideas, as well as examine issues based in science that are important to them, thus promoting scientific literacy.
- Children need to understand that scientists build on the foundations provided by the scientists who came before them and that concepts in science are underpinned by evidence that can be built upon, refuted and/or replaced (McCrory & Worthington, 2018); and
- model how scientists work in the real world by engaging children with scientific methods. The idea that scientists work in isolation must be challenged as it is simply inaccurate – in today's world, scientists are collaborative and children need to understand this if we want them to understand that science is a human endeavour to which anyone from any walk of life can contribute and be successful (McCrory & Worthington, 2018).

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Inquiry homework in primary science

● Suzanne Gatt ● Victor Ellul Bonici ● Maria Mifsud

Abstract

Inquiry-based learning in science has changed the way in which children learn science and engage with scientific phenomena. In inquiry, children explore scientific concepts and learn through questioning, gathering evidence and review. This study extends inquiry in science to homework. Children aged 9-10 in their fifth year of primary education were assigned three inquiry-based science homework tasks tackling the topics: dissolving, reflection in mirrors, and magnetism. The children were asked to test properties of different objects and materials in their home environment. The children's work was corrected and their responses analysed. Five children and the teacher were then interviewed. The study showed that it is possible to introduce inquiry-based elements in science homework. It gives children the chance to experiment with objects around the house and explore how their properties are used in everyday life. This shows how inquiry gives relevance to science as well as promoting children's interest in inquiring about the world around them.

Keywords: Inquiry-based teaching, primary school, homework

Introduction

Bringing about a pedagogical shift in the way that primary children experience science is not easy to achieve. It requires teachers to change their views of learning as well as their practices in the classroom and beyond. Inquiry is a particular pedagogical approach in science, involving questioning, collecting evidence and using this evidence to draw conclusions (Duschl & Osborne, 2002). Implementing inquiry-based learning in science is particularly demanding as it is child-centred, where children are engaged in asking questions, designing investigations to gather evidence through observation, and then to use this evidence to draw conclusions. These conclusions are then presented as possible answers to the inquiry questions set, and children need to defend them against counter-arguments put forward by their classmates and/or teacher.

There are different levels of inquiry: confirmation inquiry, structured inquiry, guided inquiry and open inquiry (Banchi & Bell, 2008). Confirmation inquiry is teacher-centred, with the teacher presenting the children with the research question and method as well as knowing the expected outcome (Gengarelly & Abrams, 2009). This is often the first step in achieving true inquiry. In structured inquiry, children are given the research question and procedure, and they then generate an explanation that is supported by the evidence collected. In guided inquiry (Abd-El-Khalick *et al*, 2004), the teacher presents the research questions and the children construct the procedure and solution themselves. Open inquiry is student-centred, as children formulate the research question, method and solution. While the level of structure and control given to the children varies, for an activity to be inquiry-based the children must be actively engaged in the task at hand (Gatt & Armeni, 2013). As the level of inquiry develops, children engage in more problem-solving and critical thinking. Teachers often shy away from inquiry because they think that they must use open inquiry straight away (Banchi & Bell, 2008), when it is actually possible to start with confirmation and move to open inquiry as children gain experience.

Homework forms part of children's daily learning tasks, which they carry out at home, and is an extension to a day of learning at school. Homework at primary level tends to be assigned by teachers as an extension to schoolwork. In some countries, such as Malta, homework (not just for science) tends to be assigned every day, or on specific days depending on school homework policies. Homework is often used to consolidate understanding of content covered and skills developed (Jha, 2006). Unless homework is well planned and engaging, it serves no real learning purpose (Epstein, 1988). It will not promote further learning and hence wastes a valuable learning opportunity. If children engage in inquiry learning at school, then inquiry activities should also be extended to homework tasks assigned.

This article presents a small study carried out with a class of primary children in Malta, and explores whether it is possible to extend inquiry science to homework. It attempts to create and analyse the effects of science homework that engages and actively involves children in further inquiry learning beyond the school day.

Theoretical framework

Homework generally involves a task to be done by students at home beyond school hours (Cooper, 1994). Its main goal is to reinforce learning, and is generally assigned following learning at school. Five key characteristics of good homework involve: a clear academic purpose of the assigned task; efficiency in demonstrating learning; ownership of tasks that are relevant to the children as well as offering options of what to do; a sense of competence as children carry out a task on their own; and an aesthetically appealing, attractive and pleasurable task (Vatterott, 2010).

Effective homework must serve a purpose. t should enable the teacher to gauge a child's understanding and competence. It also develops skills such as time-management and self-confidence (Vatterott, 2010). In science homework, teachers should avoid rote tasks involving questions such as '*Which is the largest bone in the body?*', but instead ask questions such as '*Why do you think that the femur (thigh-bone) is the largest bone in the body?*', which encourage critical thinking and where an answer reflects understanding: in this case, of the functions of the skeletal system.

Homework should not be assigned simply because of school policies that specify the amount of homework to be given every day. It should not be given as a punishment either, as it will be associated with a consequence of misbehaviour (Cooper, 1994; Epstein, 1988). Homework at primary level does not need to be sizeable. The quality of tasks given, rather than the quantity, is key to effective homework. What is crucial is that children should be encouraged to enjoy and value learning, rather than dread it.

Efficiency of homework is essential (Vatterott, 2010) and it is pointless to set homework involving memorisation. Projects that summarise content related to a particular topic mainly assess artistic ability and not understanding. Homework is efficient if it highlights cross-curricular links. A practical example is provided by Spronken-Smith *et al* (2008), who explore the question '*Where might sand dunes be on Mars?'.* In this task, students carry out research on astronomy (science) as well as sand dunes (physical geography). This example illustrates that, with some thought, teachers can create homework tasks that serve more than one purpose, hence making the process much more efficient.

Teachers can experiment with respect to what task to assign as homework, especially in the case of inquiry-based learning and other forms of discovery learning (Marzano, 2011). When a teacher plans homework carefully, focusing on children's strengths and making sure that the task is engaging, homework will be more effective (Vatterott, 2009). Having said this, it is also true that what works for one class will not necessarily work for other children in the same way.

Research shows that students who are actively engaged during science-based tasks often perform much better overall (Meece, Blumenfeld, & Hoyle, 1988). Homework tends to lead to more and better educational engagement. Students who invest more effort in their homework demonstrate more positive development in conscientiousness (Gollner *et al*, 2017). When a parent or guardian participates in homework tasks, children are more likely to complete their work and at a higher standard. Parents who sit with their children also tend to develop a better relationship with their child (Hoover-Dempsey *et al,* 2001). However, not all children benefit from homework in the same way, as some parents may not have time to help or are not capable of doing so due to their limited educational background (Darling-Hammond, 2007). On the other hand, some parents are capable of supporting their children's learning and motivate them to persist to complete the task (Lee & Bowen, 2006).

Aims of the study

This study explored whether it is possible to assign homework that is an extension of inquiry pedagogy implemented at school. The main research question reflects this focus and asks whether it is possible to have inquiry-based learning homework in science at primary level, and what impact it may have on children. The research questions set were:

- Is it possible to assign a homework task in primary science that is inquiry-based in nature?
- Does inquiry homework have any form of impact on the students' learning and attitudes to homework?

Methodology

The main methodology was qualitative, involving one primary level year engaged in inquiry homework related to the science covered at school. It involved designing the inquiry-based homework as an extension to the work done at school; assigning the homework; and then reviewing work done and interviewing five children.

The homework tasks were designed to help children develop general skills such as critical thinking, research skills and perseverance. Each homework task was divided into three sections: introducing the concept; exploring the concept; and finding an application at home. The activities started with a simple task to link the concept to the work carried out at school and an element of inquiry through a series of predictions, followed by an investigation of the application of the scientific concept in the home environment.

Three science topics were chosen: dissolving, reflections in mirrors, and magnetism, all of which were part of the children's science curriculum. The pedagogy used in all three homework tasks was guided inquiry, as the children were provided with the problem for investigation together with a list of necessary materials. Apart from this, students were expected to come up with their own way of finding a solution or result. The homework tasks also included the following aspects of inquiry: authentic activities; active student engagement; activities based on questions or problems set; making observations as part of collecting evidence; argumentation; and self-regulation (Gatt & Armeni, 2013). In the case of dissolving, children were first asked to carry out simple experiments trying out some materials found at home. The children were then asked to try to find other materials in their home and test whether these dissolved in water, or not. In the case of reflections in mirrors, the children first tested reflective properties of mirrors found in the home, and then they were invited to explore where these are used. The last task focused on magnetism, in which children were asked to explore and identify objects at home that use magnets.

One homework task was assigned every week, and data were collected over a period of three weeks from analysis of the children's homework and interviews with the children. The homework submitted by the children was analysed, quantifying the type of answers written down and objects tested. The semi-structured interviews probed the children's experiences of the homework compared to other homework tasks usually assigned. They were also asked to discuss what type of help they had received when they tackled the tasks at home. Ethical clearance to collect data was obtained from the University of Malta Research Committee.

Results

The children were surprised to receive homework in science, as this was not usual practice. Nonetheless, they did not complain and completed the tasks as requested. The majority of the children in class (21 out of 22) submitted the homework for the different topics, which shows that although voluntary, the children did do the work, due to them being aware that this science homework was not compulsory as it was part of a research exercise. In addition, in Malta there is no official summative assessment in primary science and it does not tend to be considered an 'important' subject in the primary curriculum, compared to the core subjects of English, Maltese and mathematics.

Table 1: Variety of materials tested in the inquiry tasks based on dissolving.

Type	Material	Type	Material	Type	Material
Food items	Sugar	**Food items**	Oil	**Spices, herbs**	Pepper
	Rice		Cereal		Thyme
	Butter		Teabag		Cumin
	Vinegar		Jelly powder		Curry
	Flour		Cat food		Turmeric
	Breadcrumbs		Honey		Fennel seeds
	Coffee		Ovaltine		Parsley
	Crushed biscuits		Weetabix		Nutmeg
	Ice cubes		Mustard		Salt
	Food colouring		Chocolate sauce	**Medicine**	Hydration powder
	Yoghurt		Cream of tartar	**Other**	Sand
	Butter		Worcestershire Sauce		Clay
	Hot chocolate	**Detergents**	Soap		Soil
	Jam		Shampoo		Candle wax
	Instant yeast		Fabric softener		Tissue paper
	Nutella		Dishwasher liquid		Pebbles

An analysis of the returned written work highlighted that the children were aware that it was science homework, as they attempted to use technical words such as 'melt' and 'dissolve'. They also demonstrated alternative ideas by using terms 'melt' and 'dissolve' interchangeably. In the case of the mirrors task, they linked sight to the presence/absence of light, with some children arguing that one can still see in the dark due to the mirrors. Overall, children were familiar with the properties of magnets, including knowing the appropriate technical terms, but demonstrated difficulties when using them.

The inquiry aspect targeted in the homework tasks was evident in different ways. In the dissolving task, some children went beyond predicting whether the material chosen dissolved or not, by testing their predictions. Interestingly, the children tested a wide variety of materials found in the home, as illustrated in Table 1. This reflects the children's engagement and level of inquiry promoted by the task. Different children also tested different substances, with no more than four children considering the same substance (with the exception of sugar, flour and coffee given in the task) found in the home. They also tested the behaviour of both solids and liquids, reflecting a belief that liquids can also dissolve in water. This variety of perspectives taken reflects the openness of the homework, which provided space for the children's creativity in tackling the inquiry task. It also highlights the rich environment that the home provides for inquiry in science.

These examples also demonstrate that the children went round the house and looked for substances to test. The main types of substances are found in the kitchen and included food items, herbs and spices. Detergents for washing plates as well as clothes were also considered. The children became more aware of substances that they can find around the house.

In the mirror activity, the children managed to use the mirrors to read laterally inverted scripts, the initial task that introduced properties of mirrors. They also identified a good number of objects in the home that either use mirrors or else reflect light. The children investigated the function and purpose of many shiny objects in the house. They also identified use of mirrors outside the home. The answers depict how the children opted to list items that have a shiny or reflective surface. Children chose to test both obvious and less obvious objects. They inquired about things that are part of their everyday lives, making inquiry authentic and relevant and showing growing awareness of the application of science in the world around them.

Table 2: Variety of objects identified in the inquiry tasks based on mirrors.

Type	Material	Type	Material	Type	Material
Kitchen-related objects	Foil	**Objects found in other rooms**	Stainless steel	**Other**	Water
	Chrome toaster		TV (switched off)		Glass
	Glass bottle		Plastic		Puddles
	Cutlery		Computer screen		Pools
	Pan and lid		Tiles		Soil
	Ice cubes		Iron		Fishpond
	Food colouring		Tap		Car spray paint
			Pool		Soil
	Yoghurt		Sand		Moon
	Butter		Clay		Eye
	Hot chocolate		Soil		
	Oven door		Shower handle		
	Stainless steel kettle		Pool		
	Microwave		Floor tiles		
	Ceramic bowl		Marble staircase		
	Pepper		Ring		
			Spectacles		

During the magnets task, the children tested out many items for their magnetic properties. The wide range of objects tested show how children will explore and try things out if they are given the opportunity. The large variety of items listed is impressive. The long list of things included also shows that, when given an open activity, children will explore and inquire to a greater extent than if they are given a closed and specific task.

All the children said that they enjoyed the tasks, particularly the last part, which involved inquiry: *'I enjoyed most that I started to get things from the cupboard and seeing what will happen with them'*. Children are engaged when an activity is open-ended. One child even mentioned the element of fair testing when she said that she left the substances to settle for 30 minutes and then went back to check the results. This reflects learning that had taken place in class when fair testing was used. It also showed how these children managed to get involved in actual inquiry as they formulated a hypothesis and tested it, deciding both what and how to test.

When asked about what makes these tasks different from other homework, all the children answered that, unlike usual homework, these tasks allowed them to experiment, look around the house and do more practical work. As one child stated: *'Yes, it was different because you had to experiment, not like other homework which you have to stay writing'*. *'This homework was more interesting because I had to go round and look for things, and you use your brain a little bit more!'*.

The children stated that they prefer doing such homework tasks as they have more time, can work in peace and concentrate more, feel more comfortable and can look up information on the Internet: *'I prefer doing it at home because you can find more things'*. One student did not mind whether the task was for homework or done at school, highlighting that, at school, the science teacher would be there to help with any difficulties, whereas at home one needs an adult who could help.

The children identified different things that they learned: that washing up liquid does not dissolve because the bubbles stay there; that certain objects are less reflective than others; and they were surprised that gold is not magnetic and that not all coins are magnetic.

Table 3: Objects tested for their magnetic properties.

Type	Material	Type	Material	Type	Material
Clothing-related	Socks	Appliances	Laptop	Misc.	Key
	Cap		Stereo		Bricks
	Hanger		Mobile phone		Book
	Handbag		Vacuum cleaner		Lamp pole
Stationery	Scissors		TV		Wood
	Paper clip		Sink		Ball
	Paper holder		Can opener		Fridge magnet
	Sharpener		Kettle		Pillow
	Pin		Fridge door		Coins
	Puncher		Gas heater		Soap bar
	Pen		Fan		Bicycle wheel spokes
	Table		Washing machine		Mobile phone case
	Metal door		Speakers		Bell
Kitchen-related	Cheese grater	Food items	Chocolate		Toy
	Cupboard		Bread		Spray can
	Extending dinner table		Biscuit box	Decorative items	Keychain
	Water bottle		Barometer		Birdcage
	Cupboard handle		Torch		Frame
DIY	Screwdriver				Statue

When asked about whether anyone assisted them in the homework task, the children stated that they either did the task on their own or with the help from an older sibling or parent/guardian. One child mentioned that the help of an adult was only needed to reach certain items in the cupboard and to ask permission from as to whether they could be used for scientific experiments.

Discussion

This study shows that inquiry homework can be an effective tool in extending learning to the home environment. The small cohort of children involved indicated a positive attitude toward inquiry-based homework and they were actively engaged when completing the tasks. It was possible to encourage these children to become active inquirers. Inquiry homework not only promotes practice in inquiring about the application of concepts in different contexts, but also bridges inquiry to the children's everyday life. Inquiry homework can thus contribute to making school learning relevant to children's everyday lives. Science homework is not usually assigned in Malta, as science is not formally assessed as are other core subjects in the primary curriculum. This exercise shows that homework can serve to extend learning in science and need not necessarily be directly linked to official assessment purposes, which often promote rote learning. Homework has the potential of serving a better educational purpose than consolidation of learning through drilling and practice.

The interviews highlighted how a number of children did their homework with a parent or sibling. Parental involvement in homework makes learning more effective, enhances children's enjoyment and assists in developing a positive relationship between parents and their children (Green, Walker, Hoover-Dempsey & Sandler, 2007). Inquiry can support strong home-school links, promoting the academic and social development of the child (Cox, 2005).

Children are today digitally literate, an aspect that is closely associated with greater autonomy and motivation to learn (Churchill, Fox & King, 2013). Technology also has various applications to homework, particularly the concept of collaborative learning from home. While this aspect was not explored in this study, it does raise the issue of whether the inquiry homework assigned could have been enhanced had the children communicated with each other from their own homes, through video-conferencing programmes (Brindley, Blaschke & Walti, 2009). This would allow pupils to discuss the homework tasks as a group, just as they would do in the classroom, adding an extra element of fun to homework and leading to more meaningful learning.

Correction of inquiry homework is one of the most important tasks for the teacher. First of all, it gives teachers a very good idea of what learning has taken place. By analysing these three tasks, this study was able to determine certain patterns of inquiry. In fact, the children would have probably benefited further had they had the opportunity to present their work to the class and discuss together the different substances and objects tested, as well as the various applications identified.

Conclusion

This research has shown that inquiry-based homework has the potential to be used more frequently and in a better manner in primary schools. Homework can serve as a tool to promote further learning and to produce inquisitive and inquiring minds. The idea of inquiry homework in science was successful on a small scale and can be extended to more topic areas in science, as well as types of inquiry. Although inquiry-based homework requires more dedication and collaboration between the Senior Management Team, teachers, parents and students, this study has indicated that, in the long run, the extra effort seems to be worthwhile.

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The day the balloons danced

• Ian Milne

Introduction to 'The day the balloons danced' by Amanda McCrory (Co-Editor, JES)

For this issue, we have included a contribution that will be of interest to all who work in promoting science education and have a genuine love for science. It is a reflective narrative written by Ian Milne, focusing on a workshop he ran recently for primary teachers to enable them to engage students with learning science. Milne is an experienced science educator, with a history of working as a classroom teacher, bringing his wealth of experience to work with teachers and schools in improving the teaching of primary science, which he has been doing for over twenty years.

As a science researcher, Milne has been developing a teaching and learning approach to teaching primary science entitled 'Creative Exploration' (Milne, 2017); an approach that also unreservedly fits well with the requirements of the primary science National Curriculum (2013). In particular, his approach suits the premise of learning concepts in science via 'working scientifically'. It also corresponds well with research into good teaching in primary science education, which emphasises the role of teachers in developing children's deep, yet critical, questioning skills (Hodgson, 2010; Smith; 2016) and understanding of science concepts via the creation of visual representations (Evargarou, Erduran & Mantyla, 2015). Furthermore, Milne's article highlights the importance of collaborative learning and constructivism in the primary science classroom (Skamp & Preston, 2015).

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Abstract

Sometimes in our working lives, elements of our beliefs and behaviours combine together and reward us with an aesthetic experience that reminds us of the richness of humankind, as we interact with the wonder and beauty of the natural phenomena that surrounds us on this planet. Over the last week I have been privileged to be the relief teacher for Room 21 – a class of 30 Years 5 and 6 (ages 9-11) children at a local primary school – and the facilitator for a class of 41 Years 0-3 beginning teachers at the local teacher education resource centre. The teachers were involved in a beginning teacher mentoring programme, of which my workshop entitled 'I wonder what I need to think about if I want to engage my students with their learning in science?' was part.

The children in Room 21 were having a science day with me whilst their teacher attended a professional development (PD) course for the day. We explored and experienced aspects of the natural world that usually fascinate and engage them. A relevant context was explored organically, and students used their developing understanding of and inferences from their observations of their frequent aesthetic experiences to create explanations of what they had experienced, observed and wondered about. Throughout the day, the children were required, with the facilitation of their teacher (me), to use their developing science, mathematical and literacy knowledge and skills to explore, create and test tentative explanations of the natural phenomena involved.

This short article attempts to draw together those elements of my practice and beliefs that culminated in the pandemonium created when a class of 41 adult teachers each blew up a coloured balloon and, on the count of three, released them above their heads. The resulting mayhem of balloons literally dancing around the room as they propelled themselves through the air, before succumbing to the forces of gravity and coming to rest on the floor, brought tears of delight to all involved. This moment of glee, wonder and awe reminded me of Rachel Carson's (1998) plea for teachers of young children to experience the natural world through the eyes of children. In that moment, I am sure everyone in the room returned to their childhood and experienced the actions of nature through the eyes of young children. This awe-inspiring moment kept returning to me over the last few days as I attempted to rationalise the moment through a synthesis of the elements of the practices and beliefs that informed the decisions I took, and which led to this aesthetic and enduring learning experience for those involved.

The decision to ask the teachers to blow up and release the balloons was not a spur of the moment action. It was a by-product of my work over the last ten years, as I have been developing the 'Creative Exploration' (Milne, 2017) approach to teaching and learning in science, which involves children exploring, developing and testing explanations of their aesthetic experiences of the natural world. The sense of wonder generated both collectively and individually through these experiences provides an authentic context for inquiry learning in primary school science. The emphasis of this approach has moved from just exploring the experiences to creating, testing and sharing scientifically the learners' developing explanations of the phenomena involved.
Over the last six years, I have been fortunate enough to work with science champions at a local primary school, where we have explored natural phenomena through a lens of ideas associated with the contexts of matter, energy and change over time. It was over this time that the emphasis of my teaching and the children's learning moved to creating collaborative narratives of their journey, as they explored, wondered, tested and shared their developing explanations of common aesthetic experiences of natural phenomena.

The teaching and learning approaches that I have adopted over the last twenty years for enhancing children's engagement in science were often in contrast to what has been taking place in schools. With the introduction of science capabilities and the Royal Society leadership programmes for science teachers, there has been a noticeable change for the better in many schools. Over the years, I noticed that many schools, as part of their commitment to inquiry, were developing programmes of study that were guided by deep questions relating to environmental issues affecting our lives and planet Earth.

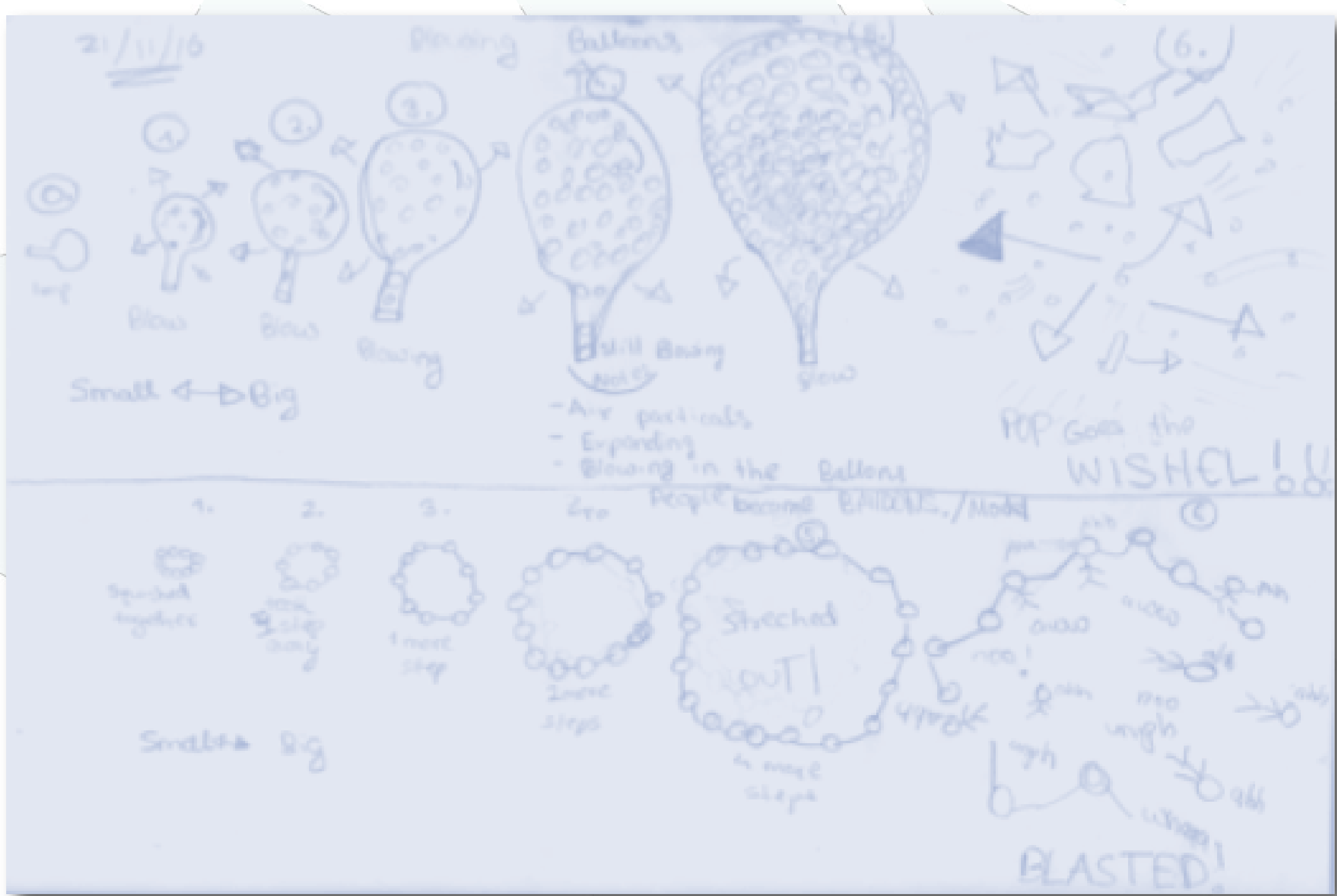
Whilst the aims and goals for developing attitudes, values and actions to protect the environment are commendable, these programmes were often video- and book-centred and children rarely explored, experienced and tested their ideas. The aesthetic experiences encountered when exploring changes that occur when energy is transferred in the context of natural phenomena provide learners with an opportunity to develop and test personal explanations of these phenomena in a scientifically, hands-on and engaging manner. This is especially the case if the contexts being explored are everyday phenomena such as air, water, sun, gravity and other related aspects, including living matter. Another feature of my work with primary-aged children is to explore how children respond to the concept that matter and energy are viewed by scientists as one and the same. Working with rubber balloons, air and energy transfer provided a relevant and authentic context within which to explore these ideas with children.

Back to the dancing balloons! A few months earlier, my science champions were exploring their ideas about energy transfer in the context of sound. We were blowing up the balloons, then letting out the air and exploring how we could change the pitch of the sounds by stretching and releasing the neck of the balloon. As the air was rushing out, causing the rubber neck to vibrate, it created sound waves that moved through the air, with some coming into contact with our eardrums. The children were engrossed in their exploration of this aesthetic experience when I casually asked the class what would happen if we let the air-filled balloons go.

A six year-old student, in a very matter of fact way, called out, *'The balloons will dance'.* She then proceeded to show the class how it would happen by moving her hands through the air above her head, demonstrating a flight path that the balloon might take as it was pushed through the air. Her imaginary balloon soared upwards, turned loop over loop, flipped sideways before suddenly stopping and dropping flat and limp to the ground. Her performance in sharing her previous experiences of playing and exploring with balloons and energy further enhanced my belief in creative exploration. My role as a teacher was now to scaffold her to develop the language and skills to explain the scientific concepts involved, so that she could share them with others. Of course, before we did this, we all blew up our balloons and watched the balloons dance around the room after we released them.

Going back to the collaborative narrative of part of Room 21's recent science day with children, we started the day by reviewing our ideas about what we mean when we use the terms 'science', 'working scientifically' and 'doing' science. We spent a little time exploring what the terms meant, including identifying that the word 'OUR' was the most important word in the review. It is important that we share the ideas that we use when creating and sharing our explanations of whatever natural phenomena we are experiencing and exploring. We then discussed what 'doing' science could look like. I read the start of a story *A Sprinkle Here, A Sprinkle There* (Anderson, 2004), about a girl who wonders what caused the salt and pepper to fall differently onto her father's sandwich whilst they were having

Figure 1: Cross-sections of the balloons' journey from a horizontal and vertical perspective (Student D).



a picnic on a breezy day. She thought that the salt might be heavier than the pepper and that the wind would blow the pepper further away as it fell out of the shaker. She drew a diagram of her thoughts, which showed the wind blowing the light pepper grains further than the salt grains. She had created a model to explain what she thought was happening. The girl decided to test out her theory. She was 'doing' science as she was testing her explanation of what she thought had happened to the pepper grains.

Next, we played with a collection of toys and materials, including James the Tank Engine, Pa Pa Energy Tubes, rubber balloons and a collection of everyday common materials. We used the toys and materials to explore different examples of energy, including sound, wind and movement. We also talked about how energy is transferred when matter/materials move/work. We spent time blowing up balloons and letting out the air. We made different sounds as we pulled the neck of the balloon apart and the air particles rushed out. Most of us let our balloons go after we had filled them with air. The balloons flew around the room before running out of energy and dropping to the floor. We even blew some up until they popped. As we blew them up, we were transferring energy from ourselves to the balloons. We could feel the particles of air pushing outwards as the particles of the balloon were stretched until they split apart and the energised air escaped.

Later in the morning, during a fitness exercise, we made a human model to demonstrate the changes that we observed as a balloon is blown up until it pops. We all linked hands and moved close together – a human model of our balloon that needed to look flat and limp. As more imaginary air was blown into the balloon, we modelled the changes by taking steps backwards. Our arms became stretched and the air kept pushing, stretching us until one of our classmates could not hold on any longer and the air exploded out of the balloon! We all collapsed and our 'balloon' was now flat and limp again. We did this several times.

The next time that we carry out this activity, we may consider modelling the air particles inside the balloon. As more children are pushed into the balloon, it will have to expand. We could also model how the balloon particles are attached to each other, by having the adjoining human 'particles' holding on to a rubber balloon, so representing the bonds between the balloon particles.

When we got back into the classroom, we created a series of annotated diagrams to explain the changes that we had observed as the balloons were blown up before being released or exploding. Student D drew two diagrams showing cross-sections of both the horizontal and vertical perspectives (see Figure 1). I compiled, with the children's help, the narrative of the events as they happened and this forms the basis of the commentary in this article.

The compilation of collaborative narratives of my work with science champions and school classes such as Room 21 has become a feature of *Creative Exploration*, developed as an outcome of my teaching and learning practice over the last six years. With the students' assistance, we have moved from filling in prepared frameworks to class PowerPoints and are now compiling collaboratively written narratives. These narratives are supported by annotated diagrams, where we share the journey we travelled as we explored, wondered and tested the developing explanations of our experiences of aspects of the natural world.

Walking back to the classroom, one child suggested that we should redo a recent class survey of the school subjects that the class likes doing best. Science had been the second most popular, behind Art. The child felt that science would now be the most popular subject if we repeated the same survey.

The teaching and learning experiences of which I have been privileged to be part whilst working with these groups of learners can also be classified as being aesthetic. It has reinforced my belief that aesthetic experiences of natural phenomena provide a valuable context within which both teachers and learners can engage with learning in science, in a sustained and purposeful manner.

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Ian Milne is a semi-retired primary science and mathematics educator and an active primary school teacher, who provides in-class support and mentoring for primary teachers and school science leaders. He also runs science champion programmes in two primary schools. When he introduces himself to teachers and children, he describes himself as a Grandad, husband, primary school teacher and science educator.

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Focusing on early childhood science – three weeks of bliss!

● Coral Campbell

As an Australian, travelling to Europe is a costly and time-consuming proposition. While I only spent 24 hours in the air each way, I have heard of others spending between 30-44 hours! So, to rationalise my trip to Europe, I decided to pack in as much as I could. Apart from starting with two weeks holiday, I attended both the ESERA conference in Dublin and the European Early Childhood Education Research Association (EECERA) conference in Bologna.

I was thrilled with the ESERA conference. The number of papers relating to early childhood science and early childhood STEM provided sessions across the whole conference. Talk about being mentally stimulated and challenged by the research being undertaken across this field! Each session provided conversations that caused me to pause and think further about my own research and the implications of this field in early childhood centres. I took copious notes to revisit on my return home. A very interesting aspect was the inter-country similarities (and differences) in terms of what was being researched, and the findings of the research.

After leaving Dublin, I travelled to Bologna for the EECERA conference. Accompanying a change of location was a change in weather: Dublin (15 degrees Celsius) to Bologna (35 degrees Celsius)! Although not as many sessions on early childhood science/STEM were listed, what was presented was interesting and aligned well with what I am doing in Australia. Several of us met over one of the lunch breaks to discuss possible further collaboration. If nothing else, it was wonderful to feel part of a much bigger community of practice. In Australia, those of us researching early childhood science and STEM are 'few and far between', meaning that opportunities for in-depth conversations with like-minded people rarely occur.

The final week in Europe was spent in Helsinki, where I had arranged to meet with academic staff at the LUMA Centre of the University of Helsinki, who are involved in science education in early childhood and early primary school. I was introduced to the LUMA philosophy, 'Joy in children's eyes', as children undertake science and maths. The work done by the Centre is impressive, as they offer a range of international research collaborations, science labs for children, workshops for teachers, interactive MOOC for parents and pre-service teachers, out-of-school activities for children, holiday 'camps' in science, and 'science' birthday parties. Their research agenda is robust, with research attached to most of their ongoing activities. I learned much in my three days of discussion with six academic staff who gave so freely of their time. It was an extraordinarily rich experience.

Whilst in Finland, I also spent a day visiting an early childhood centre located near Lappeenranta, a small town approximately 230 km northeast of Helsinki. There I met an inspiring Finnish educator who sees opportunities for science learning in just about everything that children do. She varies her approach: sometimes she uses an inquiry approach, where children's questions lead investigations, whilst at other times she uses storybooks or informal visits to museums as ways to stimulate children's ideas and further questions. We tramped through forests for a quick visit to their 'forest kinder' site and I was shown the children's video productions of weather events. Absolutely awe-inspiring!

After three weeks of intense focus on science in early childhood, it was time to return home. Whilst exhausting, it was so invigorating – I have come home with renewed energy! A big 'thank you' goes to all those involved with me over these three weeks. I didn't anticipate that so many would contribute to my learning, or that I would gain so much.

Coral Campbell, Deakin University, Australia.

News from the Primary Science Teaching Trust (PSTT)

Why and How?

The Primary Science Teaching Trust's termly newsletter

We are delighted to be able to share our newsletter. This is a termly digital production, available on our website at https://pstt.org.uk/what-we-do/why-how-newsletter

Our newsletter is very much **aimed at all teachers** and anyone with an interest in primary science.

Each issue has free pullout resources, ready for instant classroom use. These include a picture for talk in science, a whole school challenge and a piece on misconceptions and how to address them.

Please do also actively encourage others to pass our newsletter on to their networks and, if anyone would like to be added to the mailing list for it, please contact Amy Thorman on amy.thorman@pstt.org.uk

why& how?

PRIMARY SCIENCE TEACHING TRUST

The Primary Science Teaching Trust's International Science Education Conference (PSEC)

6th – 8th June 2019 in Edinburgh, Scotland

Over three days, in the beautiful city of Edinburgh, PSTT will be offering a varied and carefully chosen programme of what we know to be the very best in professional development for primary science education, delivered by experts. The programme includes: keynote speeches * practical workshops * reflective seminars * science shows * talks * social events * a primary-focused exhibition

We know that teachers value CPD sessions delivered by other practising teachers and we are delighted that our Primary Science College of award-winning teachers will be delivering workshops at PSEC. High quality contributions to the programme will also be made by our academic collaborators and strategic partners, and other world class experts in the field.

The Conference will cover the following themes:
Neuroscience and how we learn, play and early years, assessment, working scientifically, subject leadership, transition, evidence-informed practice, creativity, outdoor learning, STEM, SEND and EAL, gender bias, emotional and mental wellbeing, and information technology.

Our call for programme proposals opens in April 2018 and will close in September 2018.

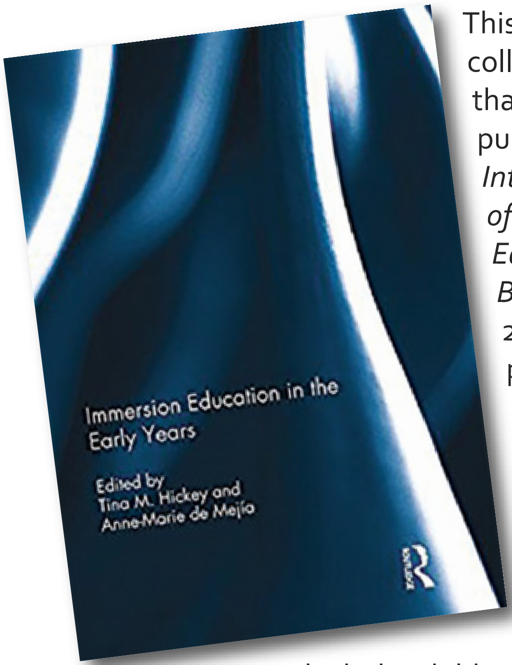
Register your interest today by visiting the Conference website: https://www.primaryscienceconference.org/ and, to be included in our conference mailing list, please contact Amy Thorman on amy.thorman@pstt.org.uk

INTERNATIONAL PSEC

Resource Review

Immersion Education in the Early Years

by: Tina M. Hickey and Anne-Marie de Mejia (Eds.).
Published in 2016 by: Routledge, Abingdon, UK
Price: £29.99
ISBN: 978-1-13830-887-9



This book includes a collection of papers that were originally published in the *International Journal of Bilingual Education and Bilingualism* in 2014. This publication was a special issue, and focused specifically on early years settings and language learning in which the children's home language was different to that in which instruction was provided at school.

There are academic contributions from the UK, Finland, Canada, Belgium, Colombia, the United States and Ireland. The chapters include examples of full or partial language immersion programmes for children between 2 and 6 years attending pre-school education. This book explores bilingualism from diverse multilingual countries, as well as provision for migrant groups. The five papers (and introduction) provide inputs of different approaches to language immersion in the early years, which reflect different philosophical approaches of early years education as well as the type and intensity of language immersion implemented.

Chapters include contributions on Spanish/English, French/English, Dutch/French, Swedish/Finnish and Welsh/English bilingualism contexts in the US, Canada, Belgium, Finland and Wales respectively. One paper presents research results about bilingualism and biliteracy skills gained by Spanish-speaking, low socio-economic status pre-school children in the United States who are experiencing English main or bilingual education. Four models (sheltered class; mainstream with pullout; mainstream with in-class support and pullout; and integrated) for revitalising francization among French Canadians are considered in a second contribution, reporting research results that show that the integrated model best promoted acquisition of French vocabulary. Another chapter tackles the educational and political context of early immersion education in the Francophone community in Belgium, and highlights the need for large-scale evaluation of the impact of this approach. Researchers from Finland present some research results on the effectiveness of immersion and highlight the importance of the educator's explicit verbalisations during adult-children joint activities to promote language learning and development. Another perspective on immersion is provided from Welsh-medium pre-schools, with children from different language backgrounds and the potential benefits of mixing children with different levels of proficiency. The last contribution focuses on the challenge of addressing dual language learning of children with language impairments and how the 'Vocabulary, Oral Language and Academic Readiness' (Volar) programme has positive and promising effects on children's language development.

These diverse contexts provide insight into the different levels of effectiveness of programmes with children in pre-school who have to develop one or two languages. While there is no clear approach to the different degrees of language experience to which children are to be exposed, the publication provides a collection of research results on the effectiveness of different programmes implemented.

The book is of interest to those educators working in pre-schools and those establishments that cater for children for whom the home language is different to that used for instruction at school, especially in areas where one finds a concentration of children from similar linguistic backgrounds but whose language is different to the national one. While the book presents mainly research results, it also provides insights into the different ways that linguistic diversity can be tackled by schools catering for young children in the early years. It also can help language policy development at regional and national level as a means of promoting social inclusion and educational success.

Although the book does not specifically focus on young children doing science and language learning, one can find a few references, in some of the texts, to how children engaging in activities together, as in the case of science exploration, can support language development.

This book is good for teacher educators and researchers interested in learning about children who are exposed to different languages at home and school, and especially where the home language is different to that used at school. It is also of interest to teachers and school management wishing to learn about how they can help children of linguistic diversity conserve their home language while also developing competence in the national language of their country of residence, and which is used for instruction at school. As the world becomes more globalised and intercultural diversity continues to grow, linguistic challenges remain relevant to today's schools in the UK and across the world. Rising up to this challenge will enable future generations not only to conserve their family cultural and linguistic heritage, but also to be able to interact proficiently in the language of the country in which they reside and grow up as citizens. This book can therefore provide literature relevant to research as well as to school practice.

Suzanne Gatt

News Roundup

Breaking gender stereotypes through early exposure

Whilst women have made notable progress in historically male-dominated fields, when it comes to technology and engineering disciplines progression in female engagement is worryingly slow. In the UK alone, the shortage of female STEM professionals is alarming, with just 8.2% of said professionals being women.

Addressing this global issue is a pressing concern; however, with STEM programmes and incentives generally focused at secondary school students, the opportunity to influence is lost.

There is clear evidence that children as young as 4 years are beginning to develop basic stereotypical attitudes based on gender. It is essential to ensure that the media play their part in creating the new 'social norms' by not perpetuating the current status quo.

Introducing Bitz & Bob – a groundbreaking, new pre-school comedy adventure!

Bitz & Bob – a co-production between CBeebies and Fremantle Kids & Family – is a pioneering animation series that aims to engage young minds through the combination of compelling storytelling with the core principles of a STEM curriculum.

Our aim is that *Bitz and Bob* can directly help children to extend, inspire and supplement their learning from a classroom setting to their homes. The characters have been designed to model key traits, activities and behaviours that are important to help children grow, e.g. thinking skills, problem-solving, the value of teamwork, early maths, expressive art, and design.

The series is underpinned by sound research and developed to foster authentic 'hands on' tasks and challenges around real life applications in STEM, with the aim of reinforcing positive messages around gender, engineering and the importance of STEM in a global environment, in practical, playful and enriching ways.

The episode structure

The core series consists of 44 11-minute long animated episodes, complemented by a 4-minute long live action companion show, *You Can Do It Too*. Episodes are powered by a single STEM concept or theme, with learning points gently embedded within the narrative of the adventure.

In the first part of each episode, the characters come across situations or materials/occurrences that will 'seed' the final solutions. The 'clues' are intrinsic to the action and comedy, but are seeded from the outset in order for Bitz to recall during her '**Engineer-o-Vision'** moment!

For example, in ***Marmalade Mayhem***, the characters are struggling to find a way to deliver marmalade on toast to a large number of customers, including a famous food critic – upping the stakes!

- *First seeded clue* – Zip and Pop drop their pencil and it rolls along the floor.
- *Second seeded clue* – Zip and Pop knock over a pile of tubes and tube-surf on them.

Bitz is inspired by the rolling tubes and envisions them being re-used as the basis for a conveyer belt to send marmalade-covered toast to the customers quickly and safely. Success!

The episode theme will be expanded in the live action companion show, *You Can Do It Too*, and supporting interactive digital content.

Vanessa Amberleigh, Executive Producer, CBeebies, says: '*We always aim to inspire our audience on CBeebies and I hope that Bitz & Bob will encourage a new generation of engineers. Bitz is a wonderful female role model; she is full of creative ideas and energy that will take our viewers on adventures that we know will fire their imaginations*'.

Bitz & Bob will launch on CBeebies from March 2018.

Contributing to JES

About the journal

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

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

- is child-centred;
- focuses on scientific development of children from birth to 11 years of age, considering the transitions from one stage to the next;
- contains easily accessible yet rigorous support for the development of professional skills;
- focuses on effective early years science practice and leadership;
- considers the implications of research into emergent science practice and provision;
- contains exemplars of good learning and development firmly based in good practice;
- supports analysis and evaluation of professional practice.

The Editorial Board

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

Contributing to the journal

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

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

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

Guidelines on written style

Contributions should be written in a clear, straightforward style, accessible to professionals and avoiding acronyms and technical jargon wherever possible and with no footnotes. The contributions should be presented as a word document (not a pdf) with double spacing and with 2cm margins.

- The first page should include the name(s) of author(s), postal and e-mail address(s) for contact.

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

Guidance on referencing

Book

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

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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.

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

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 is the biggest science education event in Europe, where over 3000 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.

The next Annual Conference runs from Wednesday 6th to Saturday 9th January 2019 at the University of Birmingham, UK – look out for details on the ASE website (www.ase.org.uk).

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

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