Electricity education for sustainable citizenship: A critical case study

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Abstract

This case study reports upon a collaborative action research project conducted in a small private nursery in South East England. The study has been developed to consider effective ways of teaching electricity in the context of education for sustainable citizenship (ESC). The pedagogical model applied in the setting is based upon SchemaPlay practice, which is founded on the assumption that cognitive development and conceptual learning is an emergent and creative individual achievement most effectively supported through free-flow play. With SchemaPlay's identification and support of children applying their dominant cognitive 'schemes' to achieve the early years (and ESC) outcomes (Athey, 2007; Siraj-Blatchford & Brock, 2016), a key question to be answered was to what extent schemes influence the children's learning of electricity.

Introduction

The nursery had completed the OMEP(UK) *Education for Sustainable Citizenship* (ESC) Bronze award in the previous year and were building upon this at the Silver level. One area of the curriculum that was identified as being in need of development was electricity, which was considered particularly challenging to the staff in theory and in practice. Given the SchemaPlay practice, an initial question was: in what way would electricity education relate to the children's schemes? SchemaPlay is a direct application of Ausubel's (2000) widely accepted principle that learning must always build upon what the child knows and can already do. SchemaPlay supports practitioners in their identification of the basic operative 'schemes' that children apply in their play (e.g. where children repeatedly spend time 'containing', 'connecting' 'positioning', rotating', 'transporting', etc.) and shows them how these may be applied to support further learning (Siraj-Blatchford & Brock, 2016). This was at first addressed in reading some of the literature on early years electricity education (Thornton & Bruton, 2007; Siraj-Blatchford, 1999) and in a staff brainstorming session, and it subsequently involved the development of resources, and a series of interventions with the children.

In a review of the professional literature, we found that there are two contrasting explanatory frameworks that could be applied to electricity in early childhood, with one relating to current flow and the construction of electrical circuits and the other to energy generation, storage and application. The common practice of beginning electricity education with experiments that use a battery and a simple lamp or buzzer to identify all materials as either 'conductors' or 'insulators' was identified as problematic. There were potential safety issues associated with the activity, as it identifies materials that can conduct as 'insulators' (Siraj-Blatchford, 1999).

Materials cannot categorically be considered essentially a conductor or insulator even in normal conditions – all materials have some 'resistance' and, in extreme circumstances, even air will conduct (as in lightning). In this project, we therefore used an electronic 'Buzz Box' (see Activities section below), because it was able to show both audibly and visually that an electrical current will flow through the human body and also through water. If electricity didn't flow through the body, then there would never be any danger of a shock and, if water was an insulator, then there would be no risks associated with having electrical devices in, for instance, the bathroom or near a swimming pool.

Siraj-Blatchford (1999) argued that a very common intuitive idea about simple circuits is that the energy 'runs out', or 'dissipates', and that this is considered a misconception to be avoided in the context of children understanding electrical current flow. In a circuit, the current does not run out when it returns to the battery. It will only be later, at a level of explanation that includes the notion of the movement of electrons, that a child will come to appreciate the reason that current may be measured at any point in a circuit and found to be the same (i.e. at both sides of the battery). So electricity and electrical circuits are best understood as a complex system where the child's progression in understanding will 'emerge' in time, as the various component features and behaviours of electricity and electrical circuits are progressively experienced and supported.

The SchemaPlay approach to electricity therefore suggested the need to build upon a child's schematic understanding and motivations for '*connecting*' and '*rotating*' to identify the passage of electricity around a circuit, and to apply the notion of 'flow', as an application of a more general and common '*trajectory*' scheme in early childhood in supporting the children's intuitive recognition of the energy 'wearing out', providing the analogical basis for a future recognition of energy flow.

Method

A Montessorian approach was adopted for selecting suitable resources, which is consistent with the schematic learning principles applied in the SchemaPlay pedagogy. Montessori developed didactic materials that provided 'materialised abstractions' – concrete materials that embody the abstract concept. For example, the Buzz Box (Figure 1 below) suited that purpose, and it had been well received by reviewers, including CLEAPSS (2000).

Following Montessori's example, the other materials were each developed to isolate a particular cognitive scheme (quality or 'sense'), to ensure that the child's attention was focused upon a particular quality. In the traditional Montessori sensorial materials, these include size, weight, shape, texture, colour, sound, or smell; in this case, for electricity education, the primary cognitive schemes were identified as the 'Circuit' (related to 'rotation'), 'Connection', and the notion of 'Energy Flow' (related to 'trajectory').

The research objectives were identified as:

- Supporting the children's emergent understanding of electricity, electrical circuits and electrical energy conservation;
- To provide controlled experiences of electrical circuits;
- To introduce switches and electrical safety; and
- To encourage the child's basic science and mathematical vocabulary.

Thornton and Bruton (2007) summarised some of the key safety principles to bear in mind when working with electricity in early childhood, and one additional provision that we added here was to avoid the use of rechargeable batteries, which can quickly become burning hot in a short circuit. We should only use rechargeable batteries where they are enclosed, and sealed by screw or tape, to avoid child access, e.g. in cameras, robotic toys, etc.

Safety first

- *Make sure that you have talked to the children about the difference between mains electricity and batteries and the dangers of touching them.*
- *Ensure that children understand that while the equipment you have given them is safe to investigate, other plugs, sockets, switches and electric lamps are not.*
- *Emphasise that batteries are safe to handle as they are, but become dangerous if they are damaged or taken to pieces.*
- *Have a safety procedure in place in your setting in the event of a light bulb being broken.*
- *Avoid children handling any form of rechargeable battery; they can cause burns when short-circuited.*

The safety advice identified online and in the professional literature generally emphasises that good habits are hard to break. Three to five year-olds can learn basic safety messages, for example, to stay away from electric sockets and to keep electrical appliances away from water.

Activities

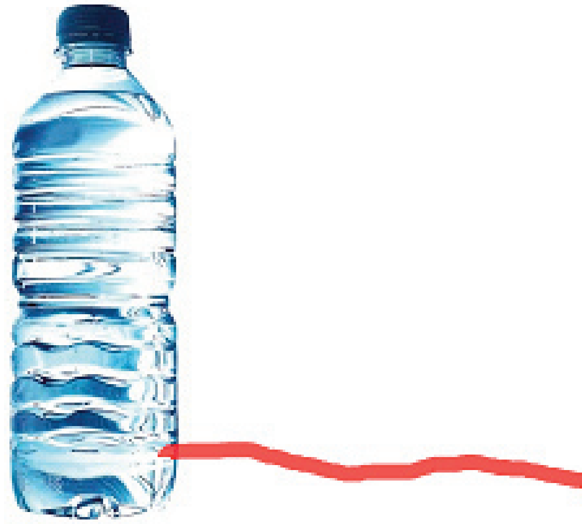
The Buzz Box – introducing the idea of electricity flowing around a complete circuit and the idea that some materials are especially good at conducting electricity, that they themselves can conduct electricity, and that most other materials conduct electricity when they are wet.

Figure 1. Buzz Box.

A Card Sort Activity – to support the children's recognition of the difference between mains and battery electrical appliances, reinforcing devices that are 'safe' (battery) and hazardous (mains). The difference in the two is described as being like water: if you have a little electricity (in a battery), it won't do you any harm as it is like a glass of water...but the mains electricity is big, it is a lot of electricity – like a river or the sea and can be very dangerous.

A 'Toy Battery' (Figure 2) was demonstrated and introduced to the water play area – to show the children how a 'battery' can be filled with pretend electricity (water) and how it 'runs out' through to a hose. The children were encouraged to pinch the tube to 'switch' it on and off. The staff kept repeating the language when they saw the children playing with it, e.g. *'Are you filling the battery?'*, *'Has all the pretend electricity run out?'* Later, the children were shown how it could be used with a waterwheel – and how this was like a motor connected in a simple circuit.
A demonstration was also later given to show how the water flow could drive a generator to produce electricity (light an LED lamp).

Figure 2. 'Water' battery.



A low voltage 'Light Board' (Figure 3) was constructed with a domestic switch and a small lamp on it to demonstrate the need for a complete circuit and the role of the switch in connecting the wires. This provided a free-to-access play resource that came to be adapted by the children in supplying electricity to other components, including a motor/propeller.

Figure 3. Light Board.

A 'turbine generator' (Figure 4) was provided, which lit a small LED lamp when spun quickly by hand or when it was turned by wind or water flow. Small electric motors generate electricity when they are spun so that the operation of a turbine like this may be improvised. This also provides a potentially valuable practical application of a 'transducer' (a device that changes energy from one form to another), and the more general (and

Figure 4a. Turbine generator.

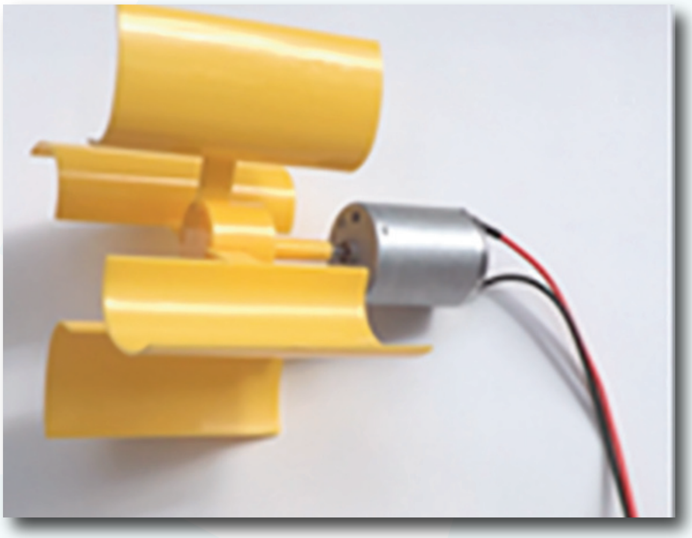


Figure 4b. Motor/propellor.

reversible) energy principle of movement energy producing electrical energy and electrical energy producing movement. The children found playing with these motor/generators particularly fascinating and they also provided a useful challenge for many in terms of their development of fine motor skills and their 'pincer grip'.

Whenever possible, the activities were used to provide an opportunity for the adults to apply appropriate language and terminology, and to talk about safety and also about electricity generations, expense, consumption and conservation.

Each of the resources was first presented to each child in a controlled (Montessori-inspired) manner, on a tray, in a room with which they were familiar and by an adult whom they knew.

The materials also needed to provide what Montessorians refer to as a 'control of error' – a means by which the child was able to self-correct. While both of these considerations were taken into account in developing the electricity resources, it was found that, in the practical realities of the children's free play, the resources were combined in unforeseen ways that will have served to undermine their didactic intentions. The children discovered in their play, for example, that the light board provided an energy source that could be applied to the motor (fan) when this was connected in parallel with the lamp. This split in the current distracted their attention from the 'circular' pathway required in the simple (one battery and one transducer) circuit.

Data collection

The case study took the form of a collaborative action research project. The project began with a short stimulus questionnaire, discussion, and a brainstorm with the five staff on how they understood electricity, how they spoke about electricity and what cognitive *schemes* they might be applying metaphorically in the process.

We shared our understandings of how a light circuit works, experimented with the Buzz Box and brainstormed suggestions on what we might try to do with the children to teach them about electricity and sustainability. All parents were informed of the project and permission to take part was sought, including from those who were selected to take part in the evaluation of the activities to be photographed and/or videoed.

These children were given pseudonyms for the purposes of the research exercise. All the children were in the pre-school group in the nursery and considered to be of a similar ability. The children were asked if they would like to participate in the study, and they were asked verbally for permission to film them. Two children did choose not to participate in the teacher-directed activities, but they did participate in the activities when they were offered as free play opportunities.

Table 1. Data collection.

Name	Age	Dominant schemes (repeated actions observed in free play)	Observed play schemes (key person notes)
Amy	53 months	Trajectory, Rotation, Transformational	Strong rotation scheme, loves stirring 'potions'
Harry	54 months	Trajectory, Rotation, Transporting, Enveloping, Positioning, Connecting	Harry was particularly interested and focused on the task [making a tower], and was keen to have a go
Lexi	53 months	Trajectory, Transporting, Containing	Enjoys role play. Loves containing and transporting when playing upstairs where they love to pretend to go on holiday to Butlins
Jack	48 months	Trajectory, Rotation, Enveloping	Jack is very interested in how things work and why. He enjoyed finding out about electricity and how we use it in different ways. Jack likes to monitor the lights in the nursery and to turn them off when they are not being used
James	54 months	Trajectory, Transporting, Containing. Rotation, Positioning, Connecting	James told us initially that he did not know what electricity was or what made the lights work

Results

Data were collected on the response of five children, and the schemes that had been identified by their key person in their unrelated play (Table 1).

The first surprise was regarding the children's knowledge of materials; while it was assumed that they would all be aware of the difference between plastic and metal, some children had not yet understood this. The discovery reminded us that we should use 'materials' words more often in our day-to-day interactions with artefacts in the nursery. We also identified the mistake that we made in including two spoons; the similarity in function, appearance and name of these all distracted from the intention of focusing the children's attention on the difference in material.

We found that the children could *easily sort electric appliances from battery appliances.* Children have now taken ownership of recycling activities and are persistent in reminding adults to switch off lights, both in the nursery and, we have been informed, at home as well. The learning objectives related to sustainable energy conservation had therefore been met to some degree.

The staff questionnaire that stimulated our initial discussions asked:

'I want you to think about when it's getting dark in the evening and you need more light to read or do something – and you ask your partner or someone else to do something about it – what do you say to them? What actual words do you use?'

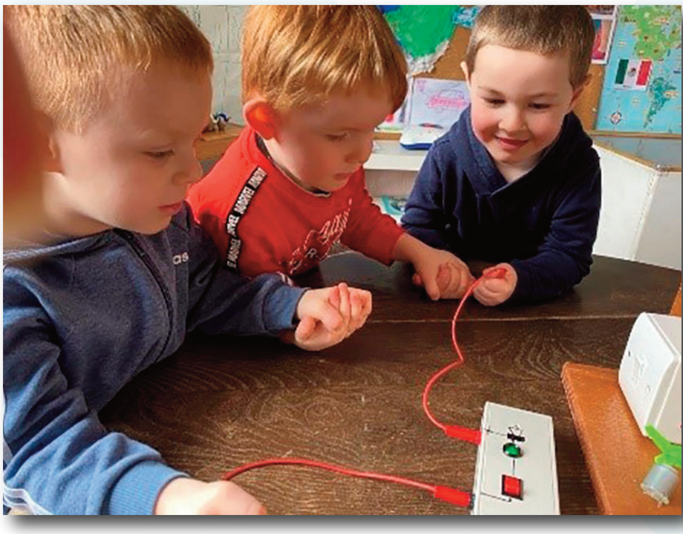
The staff responses were split between 'putting', 'turning' and 'switching'. There was general agreement that the most helpful way to say this to the children would be to 'switch the lights on'. Most of the staff also felt that this was the most accurate way of saying it, although a minority preferred 'turn it on', e.g: *'Electric comes from outside so turning the switch on lets the energy/electric in to* ***turn*** *the light on'*. Alternatives were suggested, such as *'Could you* ***push (or press)*** *the light switch, please?'* or *'click the switch'* with older children.

It is not clear where the idea of 'turning' came from, but almost half felt that it was appropriate. It may be that this is a term strongly applied in our culture because the very first switches did need to be turned (see Figure 5). Yet it seems unlikely that respondents would consider it appropriate to refer to 'cranking' the car, as opposed to 'starting' it or 'turning' the ignition. The majority (7/9) did answer by saying that 'switch' was the most appropriate term, which suggests that they felt the children should learn the proper name of the device that is used to achieve the lighting result.

When the Buzz Box circuit was completed by attaching a wire between the terminals, the children were given an audible and visual indication of the quantity of electricity passing through the circuit. When the children were given the 'hands-on' experience of sorting materials according to how well the electricity went through them, the evidence of their experiments showed that both water and they *themselves* were conductors. It provided a strong illustration of the reasons why all electrical appliances should be kept away from bathrooms, and why it is that we will experience an electric shock if a large current passes through our body.

Figure 5. Antique General Electric rotary light switch.

Figure 6. A human electric circuit.



The nursery is not a Montessori setting, and the children were therefore less familiar with the idea of trays providing dedicated self-select activities for their free-play time, and it was recognised that this would significantly influence the process and potentially limit the time spent repeating the activity in free play. However, Figure 6 shows the children having the electricity flowing through themselves in a circle during their free play with the Buzz Box. The preferred 'on/off switching' was achieved by joining hands or, even more enjoyably, by having a finger pressing the nose as a button.

Conclusions

Although this sample of children is very small, there is no doubt that teaching children to make circuits, helping them to understand different kinds of energy, consumption, etc. is not only valuable in terms of emergent learning but, more importantly, offers interesting and exciting opportunities in the early years. These were activities with meaning, the children really enjoyed them and could play with them independently – they definitely offered a new dimension to the 'classroom' – they were exciting and interactive.

While any correlation between the children's identified schemes and their developing understanding of electricity can be little more than speculative with such a small sample, it may be significant that the only child who had not been identified as applying a 'rotating' scheme in their play showed the least capability in making the circuits. Harry and James, by contrast, both having been previously identified as having 'rotating', 'positioning' and 'connecting' schemes, both took a strong interest and developed a good deal of confidence in the activities. Further research on this is warranted.

There were some physical problems with the apparatus that some of the children found difficult to overcome, and the materials need to be adapted with this in mind. For example, for many of the children, opening the crocodile clips was demanding and it was beyond the capability of some of the children to 'blow' the wind generator into action. But these challenges often provide opportunities as well as limitations. For example, the crocodile clips provided a very motivating context for the development of the children's strength in the 'pincer grip' that will support their writing.

Overall, the staff saw the activities as a positive experience that they themselves had learnt from, as well as the children:

*'The children have been interested in the electricity devices and working out how they can get them to work. One child recalled [that] if you put wood into water it conducts electricity, which I found interesting as I didn't know this' (*Practitioner Report).

For the children and the adults involved, the project has progressed very much as Sorin (2005) has described:

'Curriculum for the agentic child is co-constructed through adult-child collaboration. Adults guide the learning process, based on their own learning, life experiences and resources, and both children and adults strive to augment their understandings of issues important to them' (Woodrow, 1999, p.18).

References

Athey, C. (2007) *Extending Thought in Young Children.* London: Sage Publications

Ausubel, D.P. (2000) *The acquisition and retention of knowledge: A cognitive view.* Dordrecht: Kluwer Academic Publishers

Consortium of Local Education Authorities for the Provision of Science Services (CLEAPSS) (2000) 'The Blatchford Buzz Box', *Primary Science and Technology Newsletter*, (20)

Corsaro, W. (1997) *The Sociology of Childhood*. USA: Pine Forge Press

Siraj-Blatchford, J. (1999) *Nearly 101 things to do with a Buzz Box.* Education Now

Siraj-Blatchford, J. & Brock, L. (2016) *Putting the Schema back in to Schema Theory and Practice: an introduction to SchemaPlay.* Aldeburgh: SchemaPlay Publications

Sorin, R. (2005) 'Changing Images of Childhood, Reconceptualising Early Childhood Practice', *International Journal of Transitions in Childhood*, **1.**

Thornton, L. & Brunton, P. (2007) 'Early Years Science: Electricity', *Nursery World*, Wednesday, February 14, 2007

Woodrow, C. (1999) 'Revisiting images of the child in early childhood education: Reflections and considerations', *Australian Journal of Early Childhood*, **24,** (4), 7–12

Yelland, N. & Kilderry, A. (2005) 'Postmodernism, passion and potential for future childhoods'. In: *Critical Issues in Early Childhood Education*, Yelland, N. (Ed.). New York: Open University Press

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