Using drama within a STEM context: Developing inquiry skills and appreciating what it is to be a scientist

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Abstract

This article outlines (and evidences) how process drama can be used in a similar but contrasting way to the well-regarded 'Mantle of The Expert' approach to learning about science. In the Action Research project described here, various process drama techniques were used to purposely place 8 and 9 year-old children in specific types of 'roles' within a particular science context. The activities were designed to relate directly to the Victorian era, when machines were developed to carry out tasks in factories. The context therefore was a time when manufacturing labour-saving devices was burgeoning. In that respect, the activity is related to technology, but the skills required to design, plan, produce and test an original product relate directly to scientific inquiry competencies such as asking questions, generating new ideas and testing them. There is also a requirement to appreciate and understand how the properties of materials available at that time would be more or less appropriate to produce the final fit-for-purpose product. Children's reflections on their participation in the dramatised activities indicate that this pedagogic approach can positively address challenges, which have been noted by Ofsted to deter effective inquiry skill development.

Keywords: pedagogy; drama; inquiry skills; learner identity; working scientifically

Introduction

There are any different ways in which drama can be used to teach science. This can take a variety of forms (miming-movement, freeze-frame, hot-seating, etc.) and mean different things to teachers and children. Children tend to love drama because they *'act out'* ideas and *'move'* like something (or someone) else, use their *'imagination'* and *'get to learn stuff'* in a *'fun'* way (McGregor, 2012). Ofsted (2008: 10) recognise how it is a less formal way to learn, that it is 'exciting', 'practical', 'motivating' and even 'refreshing', because the children can 'learn by doing'. These views suggest how, because it is an active and inventive way to learn, it is a dynamic and somewhat spontaneous way to learn.

However, some teachers think of it being used in a more scripted or choreographed way, where a whole class or group 'perform' something (a song, dance or routine of illustrative movements), which is organised and structured by the teacher. In contrast to either totally child-led or teacher-led drama activities, this paper suggests an approach that involves both, with the aim of enabling the children to appreciate what it might be like to *be* a scientist and to *do* some science.

The primary National Curriculum (DfE, 2014) indicates that the nature, processes and methods of science, which require the application of inquiry skills, need to be developed within varying contexts of science (across the disciplines of biology, chemistry and physics).

The types of investigations prescribed are:

- observing over time;
- pattern-seeking;
- identifying, classifying and grouping;
- comparative and fair testing (controlled investigations); and
- researching using secondary sources.

It is suggested that, through these kinds of experimental approaches that require children to 'work scientifically' (DfE, 2014), they are then equipped with the scientific knowledge (and skills) to understand the uses and implications of science, today and for the future.

Through 'working scientifically', the programme of study in the National Curriculum identifies the inquiry skills that older primary children should nurture to grasp the nature, processes and methods of science, including:

- asking relevant questions and using different types of scientific enquiries to answer them;
- making systematic and careful observations and, where appropriate, taking accurate measurements…using a range of equipment;
- gathering, recording, classifying and presenting data in a variety of ways to help in answering questions;
- recording findings using simple language, drawings and labelled diagrams;
- reporting on findings from enquiries, including oral and written explanations or presentations of results and conclusions;
- using results to draw simple conclusions, make predictions for new values, suggest improvements and raise further questions; and
- using straightforward scientific evidence to answer questions or to support findings.

Pedagogically, Harlen (2014) identifies how the development of the kinds of inquiry skills outlined above with primary pupils presents a range of challenges for teachers. Inquiry, however, extends well beyond just 'practical work' or 'hands-on' experiences and is not just concerned with children 'discovering' for themselves, but is concerned with the development of a range of skills.

The particular skills that Harlen (2014) highlights include:

- raising questions, predicting and planning investigations;
- gathering evidence by observing and using information sources;
- analysing, interpreting and explaining; and
- communicating, arguing, reflecting and evaluating.

Ofsted (2016) recognises that these types of skills, including pupils evaluating and drawing conclusions from their science work, are limited and that this is underpinned by teachers' lack of expertise. The use of process drama to develop these skills, however, can be developed within a Dramatic Inquiry (DI). The extent to which this is possible is discussed in this article.

The Royal Society (2010: p.66), also concerned with the way in which children are prepared scientifically for the future, describe how understanding science involves much more than just the learning of facts. They highlight the importance of the development of scientific and research skills within science education, to serve two key objectives:

- to increase the scientific literacy; and
- to stretch and challenge those with the potential to become tomorrow's scientists.

This is echoed by the Confederation of British Industry (CBI) in their 2015 report, which emphasises how learning science must be addressed at the primary phase of education if schools are to nurture scientifically literate citizens for the future.

Drawing together, then, the intent of the National Curriculum (2014) to equip learners with the ability to work scientifically; Harlen's (2014) recognition that development of such skills is challenging for teachers; the concern of both the Royal Society (2010) and the CBI (2015) regarding the scientific literacy of future generations, and the evidence from Ofsted (2016) that suggests key inquiry skills such as evaluating and concluding are limited in many primary schools, the approach described here, using drama to teach scientific inquiry skills and literacy, is suggested as a way forward.

Adopting the pedagogy described in this article can enable teachers to appreciate how to support and nurture the development of a range of inquiry skills in primary science contexts. As Ofsted (2013: pp.10-11) have recognised through their regular inspections of primary and secondary schools, *'achievement is the highest where pupils were involved in planning, carrying out and evaluating investigations that, in some part, they had suggested themselves'*. This is supported by evidence that inquiry skill development was limited when *'pupils were not making decisions …'* about what to investigate or how to do something. They elaborated that, if children were only invited to *'Guess what you think will happen'*, rather than predict and explain their reasons or hypothesise (that is, suggest why they think a particular thing will happen), then development of effective inquiries was limited. They also found that contextualising the classroom activities, so that the children were able to appreciate how an inquiry might relate to their everyday lives, was more beneficial, because they found that youngsters *'learnt best when they could see how the science they were studying linked to real world experiences'* (Ofsted, 2013: p.10).

This paper suggests, then, that a teaching (or pedagogic) approach that integrates process drama with the opportunity for children to engage in a scientific inquiry, set within a technological context, can facilitate development of investigational skills. In this way, the children are able to experience 'working scientifically' through being-in-role in a sequence of different, but related, dramatised activities. They are supported in asking their own questions, and generating and testing their own possible solutions to scientific and technological problems. The adoption of the 'roles' offered to the children, in a progressive sequence, enables them to consider at length (and in depth) the contextual situations within which a scientist or technologist might have worked in a Victorian factory. Providing such a rich and immersive experience offers them many opportunities to practice and apply scientific skills (like a scientist) to solve a techological conundrum.

Therefore, the research question posed, and addressed, in this paper is: *How can different forms of drama support the development of inquiry skills in an historical and technological context?*

The historical and technological context for the drama activity was drawn from the story about the work of Mattie Knight (1838–1914). She lived in North America and became an inventor, through applying her careful and detailed observations of the ways in which things worked. She had already crafted sleds and kites for the local townsfolk. However, after a visit to a cotton mill in New Hampshire where her older brothers oversaw production, she witnessed a flying shuttle seriously injure a young boy. This was reputedly the stimulus for her to invent a safety mechanism that meant that that type of incident (where a piece of a mechanism was loose and became a safety risk) would not happen again.

The research approach

The use of process drama within the teaching of science can be used in a variety of ways, as suggested at the beginning of this paper. However, in the study reported here, it was intended that the project should be a co-operative inquiry; that is, the class of Year 5 (age 10) children and two teachers (one a scientist, the other a drama specialist) worked together in an interactive way to each other's mutual advantage. They learned from and with each other. In process drama, engagement learning activities can result in dynamic and sometimes quite spontaneous responses from the children to the guidance and/or instructions given by the teachers. In this case, in the final part of the lesson, the children were presented with the challenge of designing, producing and testing a bag that could carry different objects, using only materials available in Victorian times. The teachers were introduced to incredible innovative and unique solutions that the children collaboratively constructed. From the children's perspective, they learned a number of things about Mattie Knight and her work, how to translate a design into a real thing that was 'fit for purpose', and how to be scientific in the way in which they solved a technological problem.
The process drama in the activities (constituting a two-hour lesson) reported on here consisted of a series of related tasks. With this kind of approach, the epistemological understandings (regarding Mattie Knight's work and the nature of producing something that required scientific skills) of both children and teachers were extended (Heron & Reason, 2008).

The lesson gradually shifted from initially being teacher-led to ultimately providing much more scope for the children to be agentive in the way they worked-as-a-scientist in role. The intention, through this exploratory action research approach, was to investigate how drama might influence the development of inquiry skills in a Year 5 primary school classroom. It was hoped that the children, co-operating with the collaborating science and drama teachers, would extend their understanding of the historical influences on science and technology and develop an appreciation not only of Mattie Knight's work, but also the nature and processes involved in scientific and technological endeavours.

The school involved is located on the outskirts of Oxford, and is Ofsted-rated 'Good'. There are just over 300 pupils enrolled in this co-educational school, which has an intake from 4-11 years of age.

There is a majority of white British heritage pupils, with some ethnic minority children, mostly from Asian backgrounds. The teachers involved in teaching the intervention (as part of the action research approach) were also the researchers. A variety of mixed methods were used to assess how the children responded to the various roles with which they engaged during the drama inquiry. The data collection methods included classroom observations that focused on interaction and talk, which were collated through photographs and field notes; post-intervention questionnaires given to all the children who participated and a reflective focus group discussion that involved 3 boys and 3 girls with a range of abilities. The quotations from the children, both during and after the activities, were analysed to explore their views of their developing prowess as technologists solving a problem and, in so doing, using inquiry skills to plan, proceed and evaluate as scientists.

The approach to using process drama in the action research

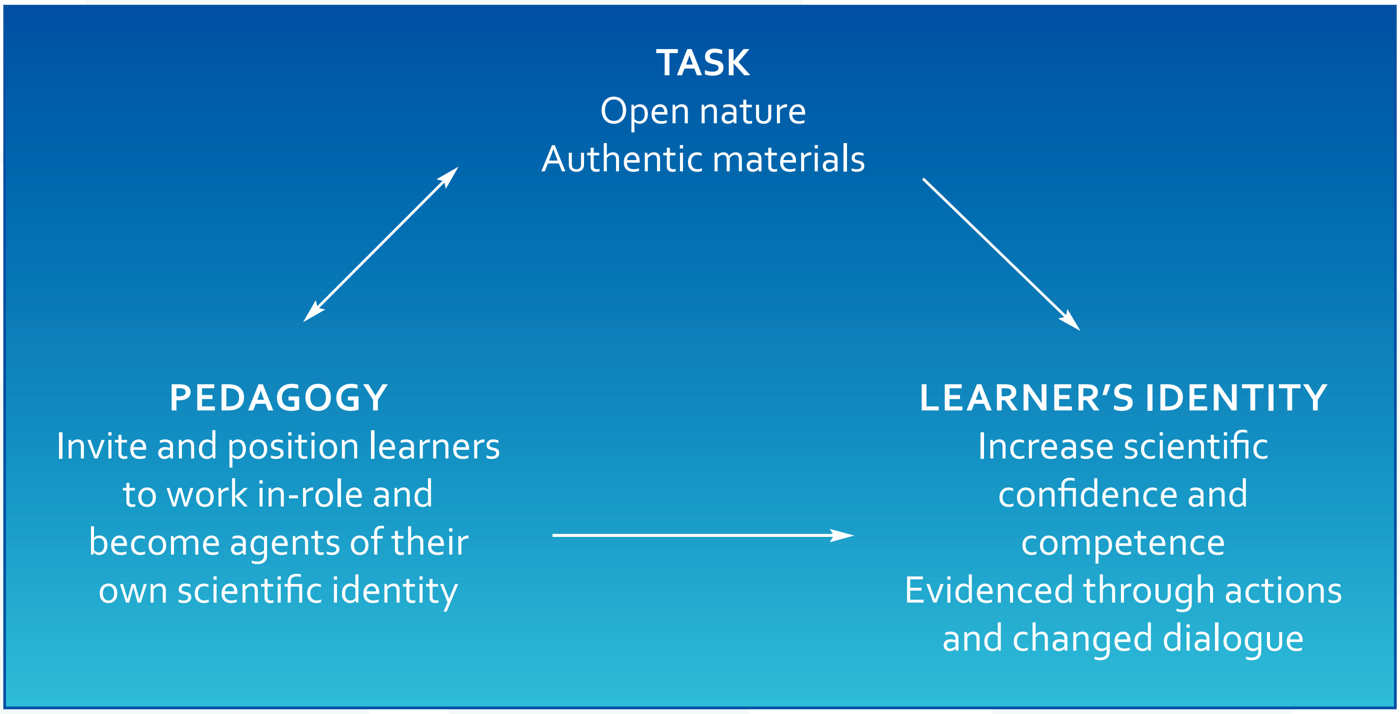
The use of drama as an interventional approach has been developed by Dorothy Heathcote (1985) and is widely recognised as an approach to develop the *Mantle of the Expert (MoTE)* in an inquiry situation.

Contrast of the *Mantle of the Expert (MoTE)* with the process drama approach, a Dramatic Inquiry (DI)

	Mantle of the Expert (Heathcote, 1985)	Process drama approach (McGregor, 2014) within a STEM context
Contextual use	Originated in the Arts (English & drama)	Originated in science to support *Working Scientifically* (DfE, 2014) and extend development of inquiry skills
Timescale	Extended over several weeks Several classroom episodes	A lesson of 2 hours
Approach	Provide 'as if' (p.61 in Swanson, 2015) opportunities.	To develop a gradually immersive experience with the finale of being 'a scientist in role'
Position	Provide 'to pretend to be' opportunities...in various roles... Progressive, from company employee to expert scientist	Includes a range of positions (see Table 2), developing from being a machine, an expert technologist, member of patent committee Immersive
Extent of authenticity Roles Materials Task	Working-in-role as someone involved in the 'Inquiry' Individuals retain a role Artefacts (documents, reports, photographs, etc.) An inquiry to explore something	Working-in-role with others as a team of scientists Collaborating mini-communities of inquiring scientists Late 19th Century resources Design an original carrier (bag)
Analysis of impact	Reflectively considering dialogic development and (various) outcomes at end of inquiry	Post-intervention questionnaire Dialogue analysis Group interviews with learners Artefacts produced as an outcome of the task

Table 1: An illustration of key differences in the *Mantle of the Expert (MoTE)* approach and the Dramatic Inquiry (DI).

Figure 1: A diagram indicating how the teaching (pedagogic approach adopted) that involved a particular kind of open task, using authentic materials, would support development of the children's identities as more capable scientists.



She explains how this approach enables students to 'see' themselves as they demonstrate others' ways of being and working. She also indicates how visibility of ideas can offer possibilities for improvement. She highlights how the inquiry tasks can offer a 'realistic' experience and that students will *feel* that they are behaving with authenticity. This STEM inquiry has been developed with Heathcote's (1985) *MoTE* in mind. However, the process drama approach to science used in this project has been designed to allow teachers to easily adopt it. There are some similarities and differences (see Table 1) in the two approaches. The whole (DI) activity can be implemented in two hours. In trialling the materials and approach, an afternoon in the school day was utilised for the Mattie Knight inquiry.

The theoretical model underpinning the way the intervention was developed

The action research approach assumed the use of authentic Victorian materials (see Figure 2 below) and a task within the DI that was open-ended, that is, there was not a single solution anticipated and the children could produce a wide range of different responses. It was essential in the intervention that children were invited to work-in-role as a sequence of immersive activities. The pedagogic steps in the DI are summarised in Table 2 (below). The authentic materials used in the activity for the design task were: sacking or hessian, brown paper, gummed paper (with a damp sponge in an old tin to wet it), string, scissors, needle, thread, assorted buttons and brass split pins. It was anticipated that the children would be agentive and develop their skills and understanding of being a scientist in the successive positions in which they were placed, and the associated roles they undertook. It was hoped that their confidence and competence would increase as they worked collaboratively with others in their class on the various dramatised activities.

How did the teacher develop the Dramatic Inquiry (DI) (the pedagogic approach) to 'position' the learners?

To help the children engage in the DI as scientists, it was important that they quickly became immersed in the Victorian factory context in which Mattie Knight worked. To help 'set the scene' and provide a purpose for designing an original bag, there were successive activities framed to help them appreciate why an original bag design was needed. The children were engaged in participating in-role in a variety of ways, as summarised in Table 2:

Table 2: A summary of the teacher's pedagogic approaches that were intended to place the children in particular kinds of positions to think, learn and be a scientist-in-role in Victorian times.

Teacher Approach to develop the DI	Position of learners
Inviting the children to imagine the doorway into a big Victorian factory building. Subsequently sharing pictures of Victorian factory machines involved in manufacturing paper bags. Children were asked to work in groups and 'move' as a working machine	As a virtual visitor to a late 19th Century (Victorian) factory
Inviting the children who would help carry shopping in a cone-shaped bag to consider the issues for packing heavy and light things, carrying soft fruit or eggs all the way home and then placing the bag on a counter top ready for unpacking	Technologist thinking about issues and possible (re)design of the cone-shaped bag used at the time
Inviting the children to work together to design, make and test a bag to carry a particular object, or several things	Collaborating technologists and scientists inventing (designing and making) an original object (a bag) to solve a 'real' problem
Inviting the children to create a written document (poster) that describes what their original design is and how it would work. They have to explain how it is original, justify their use of particular materials for different parts of the bag, and demonstrate how it is 'fit for purpose'	A technological and scientific team presenting and explaining how their invention works, what is original about it and justifying how it is 'fit-for-purpose'
Inviting the children to listen to presentations from each group developing an original bag and then judging the originality and functionality, before agreeing to award a 'patent' certificate	A patent committee member judging the originality, functionality and explanation of a group's invention

Figure 2: Illustrations of some of the authentic materials used by the children.

Data gathering

Various forms of data were gathered via reflective questionnaires that the children completed. The particular focus of the questions sought to ascertain the children's self-reports on their views of the ways that the drama activities had promoted:

- asking questions;
- thinking of new ideas;
- testing ideas;
- explaining things;
- observing how things change;
- comparing things;
- seeing patterns;
- using evidence to make conclusions;
- using scientific words;
- making decisions like a scientist;
- thinking like a scientist;
- acting like a scientist; and
- being a scientist.

There were also focus group discussions after the lesson, supplemented by audio-recordings of the lesson taught and the teachers' reflective field notes.

Findings

The children's responses were collated, sorted and then ordered, applying principles that Creswell and Plano Clark (2007) offer to 'transform' data in order to look at it in different ways. The utterances during and after the lesson were also transcribed to enable a thematic analysis (Corbin & Strauss, 2015). The transcriptions of the lesson and the focus group discussion were analysed with two key theories in mind: Urrieta's (2007) notion of figured worlds to consider how the children negiotiated and performed their identities (as well as acknowledging others and artefacts) within the Victorian context of designing and making a bag; and Wenger's (2001) view of narratives of self, applied to explore how the participating children might conceive their learning trajectories within the series of drama activities.

The analysis of the questionnaires (see Table 3) suggested that *all* the children thought the DI supported them in 'asking questions', 'thinking of new ideas' and 'using scientific words'.

Table 3: Collated responses garnered through the questionnaires, from the class of children (n=22), to indicate which inquiry skills they thought they developed through the DI.

	% Children's responses after the intervention lesson
Asking questions	100
Thinking of new ideas	100
Using scientific words	100
Testing ideas	96

This view was exemplified by one boy who said confidently at the end of the lesson, *'Normal science lessons – mixing and solving stuff…but this you were using your imagination as well and creativity which I really like'.*

	% Children's responses after the intervention lesson
Thinking like a scientist	96
Acting like a scientist	96
Being a scientist	96
Making decisions like a scientist	86

Table 4: Collated responses garnered through the questionnaires, from the class of children (n=22), to indicate how far they thought they were behaving and thinking like a scientist through the DI.

Interestingly, when the children were asked to consider how much the DI helped them 'think', 'act', 'make decisions like a scientist' and feel like they were *being* a scientist, the vast majority of the class (see Table 4) thought they did a great deal. To exemplify this, one girl stated that:

'*you could see the reason behind why we were making bags and we were using the materials that they had back in that time*'; another said, '*it got your mind thinking about how you can use things from that era*'. One boy added that he felt they were '*grappling with stuff from Mattie Knight's time*'. The way that using authentic materials really helped them think more deeply was suggested by one girl, who explained that '*it made me feel like Mattie because we were using all the materials from her time and you couldn't just use what you wanted*'. They felt that they had to think '*more*', '*imagine and…paint a picture in your head*' and that demanded much more concentration, because '*you put yourself in another person's shoes*'.

When questioned further about what they enjoyed about working-in-role as a scientist?

Children indicated that they enjoyed themselves more than usual because there was more likelihood of unplanned happenings in the lesson and it wasn't the normal *listen*, *do* and *write up what we did* kind of lesson. Their responses suggested that it was enjoyable because, as one boy explained, '*you know something fun is going to happen*'. Asked about how they felt when in role, they explained it made them feel '*excited*', that they were in '*a whole different world with a team of scientists*' and that everyone in the class '*was a scientist*'. One of the older girls, whose parents were both scientists, highlighted how many of them appeared to feel, saying, '*it made me want to be a scientist*'. The opportunity to act and think in role as a scientist really seemed to inspire them! Their learning trajectories, it seemed, shifted beyond just achieving in the classroom, with some stating that they understood what it was to '*be a scientist'* and even '*wished*' to be one…and thought they '*could be as scientist one day*'.

Conclusions

Althrough this was only a small-scale study with one Year 4 class (of 8-9 year-olds), the objective – to explore whether the use of dramatic inquiry could 'shift' children's identities from thinking that science was too hard and difficult to considering how they might succeed in science, and even wish to 'become' a scientist – appeared to have been achieved.

There was evidence that various inquiry skills were developed, as well as the children developing their identities as scientists. This project, therefore, suggests that teachers can 'set up' learning experiences (using appropriate tasks and authentic materials) to support children believing that they *do* science and could even *become* a scientist one day. As Brock *et al* (2006) suggest, we should not consider identity as a fixed entity, but rather one that is fluid and dynamic and that can be shaped and influenced by inspirational activities in classroom settings.

This project, by developing a dramatised scientific inquiry that positioned learners differently at successive points in the lesson, not only illuminated for the children different dimensions of scientific understanding, but also extended their appreciation of what it was to think, act and be scientific. By using drama, there appears to be a huge potential to also enrich children's scientific literacy, so that they are no longer turned off science, but are excited and motivated by it. It appears that they feel they can apply and understand a vocabulary-heavy subject and their personal curiosity can be fulfilled to some extent. They certainly demonstrated how they were able to develop investigative, questioning and thinking skills to a noticeable extent, not only for themselves, but also so that their teachers could recognise this in their 'roles' as scientists.

It appears, then, that a Dramatic Inquiry (DI), pedagogically set up in the way that is outlined in this article, can:

- Extend children's experiences of and engagement with inquiry skills;
- Hone children's questioning and thinking skills;
- Promote a phenomenological empathy with someone (from history) doing scientific work;
- Enhance children's appreciation of the ways in which science is relevant and useful to everyday life;
- Enable children to more strongly identify with *being* a scientist;
- Illustrate the impact of an innovative curricular approach on the development of children's scientific and learning identity;
- Promote an individual's identity in various ways as a scientist, from just 'thinking like', to believing that they are 'being like', a scientist;

- Show that working collaboratively with others, on an authentic task, can enhance the range of inquiry skills developed; and
- Show that the children re-constructed different aspects of themselves (as a technologist and scientist) and gained different perspectives when placed in new and different situations as learners '…*because they are afforded*' (Holland *et al*, 1998) different perspectives through engagement in the strongly contextualised tasks.

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