# Chapter 12
# From slavery to scientist: Dramatising an historical story to creatively engage learners in resolving STEM problems

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**Abstract**
The involvement of children in dramatic inquiry, through activities that introduce how scientists and technologists have worked in the past can 'set-the-scene' to engage them in practising STEM skills within a problem-solving situation. Historical stories can potentially provide rich, authentic contexts that engage children in imaginatively and creatively STEM-based challenges. In this chapter we describe how a sequence of dramatised activities enabled children to think about scientific and technological issues that were pertinent in the life and work of George Washington Carver (GWC), an American born into slavery. The children worked in-role, as GWC in dramatised inquiry activities, designing their own methods to investigate soil quality and plant growth and to explore how different plant parts might be mashed, ground, dissolved, sieved, mixed and heated to make different products including ink, paints, pastes, creams and drinks. We describe how an Action Research approach was adopted, using a mixed methods to collect the impact data. Data collected included field notes, informal discussions, interviews and questionnaires. Scrutiny of the data suggested that by participating in dramatised activities, learning became more meaningful for the children as they became inquirers through empathising with Carver's situation as a scientist and technologist. The impact of the creative pedagogy, immersing children in an alternate, historical context, extended the STEM inquiry affordances made available to them. The interventional project not only increased pupils' engagement, learning about science and generating original ideas but it also demonstrated how teachers could be creative in STEM teaching. Outcomes from the project suggest seven distinctive affordances which can support creative inquiry in STEM learning contexts.

## Introduction
This chapter describes how a sequence of drama activities informed by the life and work of George Washington Carver (GWC) were adopted to engage children in STEM inquiry activities. Although research into the ways that a historical story can be brought to life to extend affordances for pupils has been demonstrated by others (McGregor and Precious, 2015; Swanson, 2016; McGregor et al., 2019), this chapter focusses specifically on the story of GWC, an American born into slavery, who worked with local farmers to improve their agricultural practices and develop a wide range of products from plants, including dyes and adhesives. Adopting a socio-cultural lens for the project, this chapter highlights how: i. it included the exploration of the context in which the scientist was working; ii. it adopted a framing of an imagined, figured world (Rainio, 2008) constructed through the application of

a series of drama conventions (summarised in Table 1), and finally; iii, suggested how inquiry practices (Table 2) could be used to solve a STEM problem. The intervention also demonstrated how the nature of science can be better understood by pupils given a chance to be immersed in an historical context and work-in-role as a scientist within that setting (Table 3).

The features of an intervention highlighted in this chapter demonstrate the sequential use of a series of different drama conventions to immerse a group of pupils, aged 10 – 11 years, in thinking about a historical context. In responding to their inquiry questions, the pupils drew on aspects of the scientists's life [GWC] and considered how he resolved the challenges he faced during his life in the deep south of America, where poor farmers struggled to increase their annual yield of cotton (and other crops).

The activities were carried out in science lessons with a view to the children understanding more about plant growth. They were able to familiarise themselves with GWC's life and his work in early 20th century America. Specifically, he explored ways that different plants (or their parts including the peanut) might be mashed, ground, dissolved, sieved, mixed and heated to make different products including ink, paints, pastes, adhesives etc. He also recognised how impoverished soils impacted negatively on the agricultural yield of crops and that leguminous peanut plants, that restored nitrogenous content to the soil, were invaluable in crop rotation.

The Action Research (AR) design (summarised in Figure 1) included examining the impact of the various drama conventions. We adopted a mixed methods (Woodhouse and McGregor, 2016) approach to collect impact data (including field notes, photo-documentation, interviews and reflective questionnaires). This approach enabled us to address the question 'How can a dramatised inquiry, informed by George Washington Carver's historical story, support pupils' STEM learning? Scrutiny of the evidence, from the data collected, suggested that by providing dramatised activities that explained and justified an authentic problem context, learning became more meaningful for the pupils. They naturalistically used their ingenuity and creativity as they empathised with being a scientist or technologist in their inquiries. The conclusion of the chapter offers generalised principles for dramatising STEM learning that draws on other scientists' and technologists' stories to promote inquiry practices.

**Theorising the nature of creativity**

The nature of creativity and the ways it is defined are still contestable today. In 1950, over 70 years ago, during a keynote speech, at the American Psychological Association, Guildford highlighted the need to clarify the educative nature of creativity. More recently concerns around clarifying what such an entity might look like across the disciplines identified how an artist, inventor or craftsman might recognise and cultivate creativity differently (Glăveanu, 2017). Over the past few decades though, because of the juxtaposed way that teachers of English, the Arts or Sciences might understand and interpret creativity, it is not always clear ‘what’ it is or indeed how to ‘best’ support it (Kamphylis et al., 2009). This is especially challenging when considering the multitude of definitions of creativity that are presented for teachers to consider. Welch (1980), for example, cited in Isaken, (1987, p. 9) reviewed twenty-two descriptions of creativity, whilst Rhodes (1961) reported over fifty-six. He went on to say that, whilst numerous, these definitions were not “mutually exclusive” (*ibid*, p. 307) because:

> “…they overlap and intertwine. When analysed, as through a prism, the content of the definitions form four strands. Each strand has a unique identity academically, but only in unity do the four strands operate functionally” (*ibid*, p. 307).

The four strands interacting ‘in unity’ were labelled by Rhodes (1961) as “the four P’s of creativity”. They were:

1) “the person” - the “personality, intellect, temperament, physique, traits, habits, attitudes, self-concept, value systems, defense mechanisms, and behaviour” (*ibid*, p.307)
2) “the process” - which “…applies to motivation, perception, learning, thinking, and communicating” (*ibid*, p. 308),
3) “the product” - which is when “… a thought [an idea]…has been communicated to other people in the form of words, paint, clay, metal, stone, fabric, or other material” (*ibid*, p. 309) and
4) “the press” - which constitutes “…the relationship between human beings and their environment” (ibid, p. 308) because “no-one can perceive a person living or operating in a vacuum” (*ibid*, p. 305).

However, as Isaken (1987) pointed out, this perspective of creativity, which appeared to incorporate all human beings regardless of age, or their perceived ability, retained a definition, but it was so general it was not directly useful to apply in educational settings. More recently the four Ps have been revisited by Murcia et al. (2020) in the development of their A to E framework. Glăveanu (2013, p. 69) also reconsidered the four P’s and proposed an alternate framework, the “5A’s, actor, action, artefact, audience and affordances”. He argued that the 5A’s better embraced a socio-cultural approach, which offered a more comprehensive perspective of creativity. This more ecological approach to creativity is acknowledged in this chapter through recognition of the ways various affordances are embraced within the approach that adopts drama conventions to frame and develop children’s immersion in an historical context and subsequent engagement in inquiry.

The increasing educational interest in creativity arguably emanates from the Programme for International Student Assessment (PISA) announcing its planned inclusion in the 2021 tests (OECD, 2019). Although it has been suggested that international testing of creativity will produce a narrow vision of creative skills (Guror, 2016), there has long been a concern in the United Kingdom that creativity is supported in school classrooms. In 1999 the then

Secretary of State for Culture, Media and Sport, invited Sir Ken Robinson to form the National Advisory Committee on Cultural and Creative Education (NACCCE). This committee attempted to define creativity for both primary and secondary education. NACCCE defined creativity as, "… [an i]maginative activity fashioned so as to produce outcomes that are both original and of value" (NACCCE, 1999, p. 30). They clarified *teaching creatively* (TC) as that where "…teachers using imaginative approaches" could make "learning more interesting, exciting and effective" (NACCCE, 1999, p. 102) and '*teaching for creativity*' (T4C) designed to promote learner creativity was a form of teaching "…intended to develop young people's own creative thinking or behaviour" (*ibid*, p. 103). These two perspectives, evidenced in the project reported on in this chapter, also clearly relate to Murcia et al.'s (2020) view and Glăveanu's (2020) 5A's framework.

Organisations, such as the Office for Standards in Education (Ofsted) in England, which ensures that providers of education, training and care services maintain high standards for pupils through regulatory inspections, have more recently promoted elements of creative practice. They indicated how teachers "…encouraging pupils to question and challenge, make connections and see relationships, speculate, keep options open while pursuing a line of enquiry, and reflect critically on ideas, actions and results" could support more creativity in inquiry (Ofsted 2010, pp. 5-6). Whilst these qualities have been associated with that of a scientist, as suggested by McGregor and Precious (2015), simply acknowledging these features in policy documents (DfE, 2014) is not enough to promote scientific creativity in England's classrooms (McGregor and Frodsham, 2019). Teachers also need clarity to realise how to extend affordances (Glăveanu, 2020) and develop pedagogic strategies that actively encourage their pupils to *act* as scientists; engage in scientific *actions*; produce relevant scientific *artefacts* and in so doing respond to the ways that material, visual and cognitive opportunities to be creative are offered to them.

Glăveanu (2011) also identified interactional features, that were dialogic and symbolic in nature, and promoted collaboration. In such creative environments, pupils engaged with others in collective endeavours that supported sense making and the construction of understanding. Rainio (2008) extends this and describes how teachers develop a classroom into an imagined, figured world, where material artefacts and particular kinds of tasks enable learners, of any age, to take-up different roles; giving them a better appreciation of cultural influences shaping how they come to know things. McGregor et al. (2019) adopted these notions to illustrate how drama provides the opportunity to gradually re-position pupils to become 'scientists-in-role' so that they could verbally and actionally make decisions and solve scientific problems through inquiry. The creative teacher in this project generated an imagined world in the science classroom that related to GWC's social, historical and cultural context, and offered opportunities for pupils to engage in imaginative thinking and creative problem solving.

**The creative use of drama conventions to promote inquiry**

Engaging in solving scientific problems, provides pupils with opportunities to practise and apply inquiry skills (Osborne, 2014). The framing of the dramatic inquiry in the GWC project offered opportunities for children to practise being agentive, to think and work scientifically, consider and argue about meanings and relevancy of data. McGregor et al. (2019) illustrated how the pedagogical methodology of introducing an 'as if' context offered an approach that overcame many issues previously recognised as barriers to learning through inquiry (Minner et al., 2010; Harlen, 2011). Immersing the pupils into a historical context, providing an open question for inquiry, and providing materials associated with the imagined world, enabled the pupils to actively respond, engage and credibly solve an authentic issue. The resolution of an open inquiry is not pre-determined, hence, alongside developing scientific literacy (Taber, 2011), it contributes to understanding the creative element within the nature of science (Lederman at al., 2013). Arguably, by 'setting-up' situations in which pupils could think and behave with purpose, teachers provide opportunities for pupils to work as scientists-in-role (e.g., describing observations, clarifying thinking, justify claims, and clearly and persuasively using evidence) which, builds an understanding of the nature of the work carried out by scientists.

Just as McGregor and Precious (2015), Swanson (2016), Stagg (2020) and McGregor et al. (2019) indicated this approach suggests a third kind of location in the "as-if" dramatised (or re-configured) world, that can extend affordances for pupils to actively participate with thinking, making-decisions and taking action; thus experiencing an inquiry processes. This extends Craft's (2001) notion of possibility thinking. Key features of the experiences described by these authors included different ways of positioning the pupils in a figured world context. For example:

- Immerse themselves in the context of an 'as-if' figured world (Rainio, 2008)
- Enable participation in activities related to the scientist's historical and scientific context
- Engage them in a purposeful, appropriate, contextualised and open challenging activity
- Promote collaboration through working together in-role as groups of would-be-scientists

These features offered learning experiences that enabled pupils to appreciate what it is like to work as a scientist, to think and act scientifically through being afforded opportunities to creatively solve accessible STEM problems.

**Exploring ways of using historical stories for promoting learning**

The involvement of pupils in dramatic inquiry, through activities that introduce how scientists/technologists have worked in the past can 'set-the-scene' for the development of creative thinking and STEM enquiry skills within a problem-solving situation. Historical stories can provide rich authentic contexts that engage pupils to imaginatively and creatively resolve STEM-based challenges. Engaging in a dramatic inquiry, framed as a story of well-known (or not so well known) scientists, can inspire and motivate pupils to discern and empathise with the the work of a scientist (McGregor, 2016; McGregor et al., 2019). Through designing learning opportunities in which ideas are challenged, pupils can ask questions, see connections, discern patterns in data, process information, plan and carry out investigations, critique others' suggestions and utilise resources to make something work. These kinds of process skills contribute to creative thinking and support pupils to generate unique solutions to STEM problems.

For example, McGregor and Precious (2015, p. 171-227) illustrated, by drawing on stories from history, how inquiry activities (*ibid,* p.121 – 124) could be presented to pupils in ways that prompted their thinking about the work of scientists from history or ways for solving open problems relating to the work of scientists today. Swanson (2016) also illustrated how pupils placed in the position of scientists, acting in role to investigate the sinking of the Wahine (a well-known New Zealand boat that sank in Wellington harbour in 1968), felt they worked like real scientists. Swanson demonstrated how the discussion and scientific thinking of the pupils was positively influenced by the adoption of an inquiry approach. Stagg (2020) identified a similar effect when exploring how an external visitor, an actor in role as Linneaus, impacted and augmented the botanical lexicon used by the pupils when they were discussing plants. Understanding of the nature of science and the associated inquiry practices were all improved by pupils being immersed in purposeful dramatised contexts, as observed in both the England and New Zealand cases (McGregor et al., 2019).

**The historical story drawn on to inform this dramatic STEM inquiry**

One of the narratives drawn on by McGregor et al. (2019) related to a historical story of the work of a technological scientist. This chapter focuses on a different character, (GWC), who, although born into slavery became a scientist and inventor. His careful observations, examination of soil nutrients and recognition that some plant crops depleted nitrogenous content and others enriched it, led him to develop his ideas about systematic crop rotation. GWC also demonstrated how new plants (such as peanuts, soybeans, pecans and sweet potatoes) could be profitably grown between the cotton crps. He conceived of over 300 applications for the peanut alone (American Chemical Society, 2005) which included a range of food stuffs and even other substances such as axle grease. These unique products were useful and economically valuable for poor farmers living in the deep south. The story of GWC demonstrated how his creativity was essential to solve problems. This historical narrative provided the context for a creative STEM inquiry.

**The Action Research Approach**

This research was conducted in a suburban Church of England Voluntary Aided state school in England. The school was located in a low-socio-economic area with roughly 200 pupils enrolled, ranging from 4 to 11 years. The final year class of 10 to 11 year old pupils, having roughly equal proportions of boys and girls and a small number of Black, Asian and Minority Ethnic pupils, engaged in the action research project.

The Action Research approach, summarised in Figure 1, was adopted to explore how a dramatised inquiry, informed by GWC's historical story, supported pupils' STEM learning.

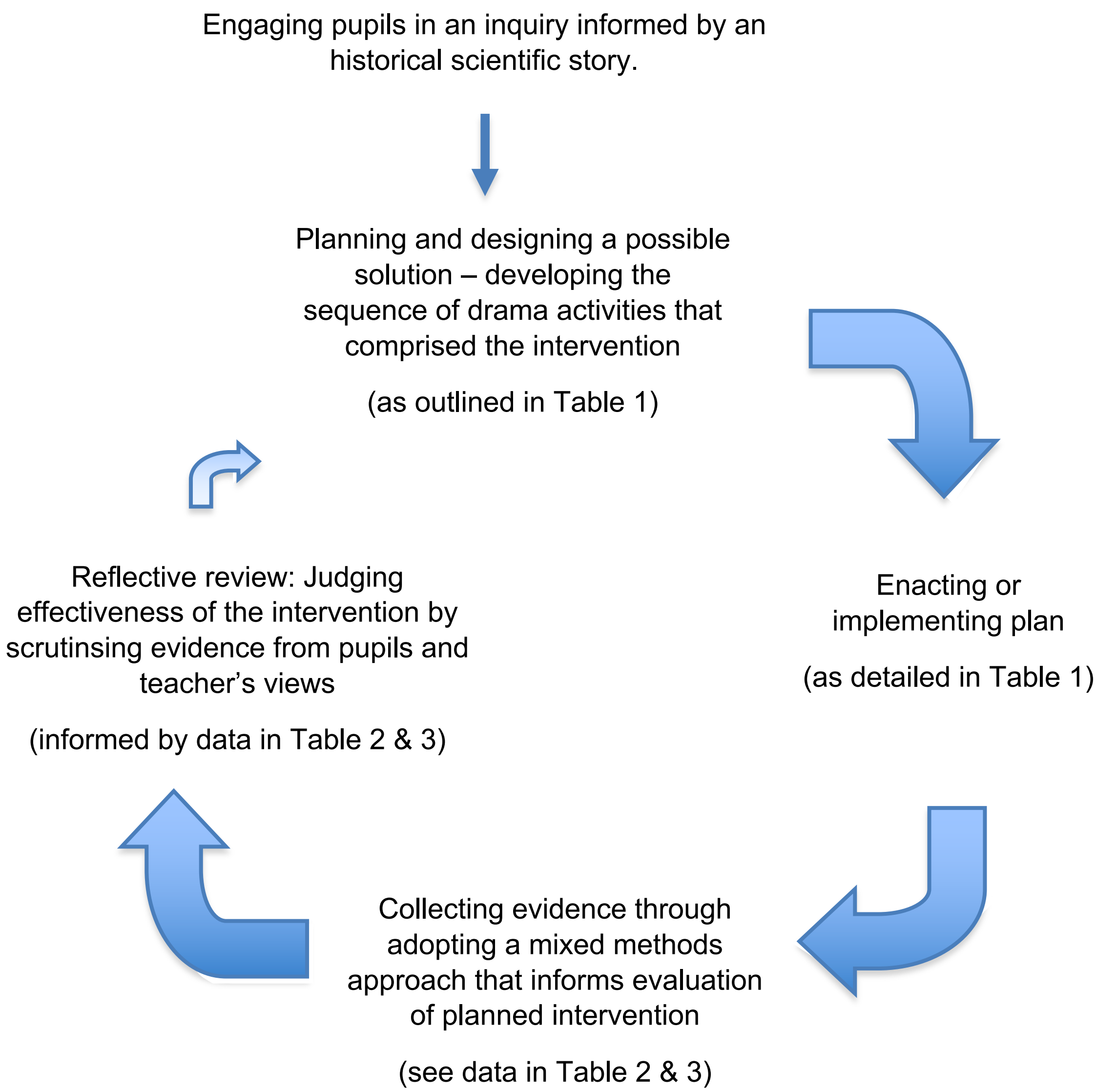


**Figure 1: Outline of the Action Research Approach described in this chapter** (Adapted from McNiff and Whitehead 2002 p. 41)

It should be noted that evidence and findings from this cycle of research activities, informed a second action cycle, but this is not reported on in this chapter. The pupils' classroom teacher collaborated with researchers, facilitated the activities and contributed to reflective analysis. Impact data was collected using mixed methods and included field notes, informal discussions, interviews and photographs. Each method, as elaborated below, contributed different forms of data that provided evidence indicating how adaptation of an imagined dramatised world of GWC promoted understandings about the nature of science and learner creativity.

- **Digital Still Images**: Photographs taken by the teacher-collaborator were transformed into line-illustrations of pupils involvement in the drama conventions and development of creative outcomes (Figures 2-6)

- **Researchers' field notes:** Observations of teacher behaviours, nature of tasks presented, use of cultural artefacts, discussion with pupils, and learner responses to the drama activities (Table 2)

- **Interviews and teachers reflective journalling**: Illustrative quotations were drawn from both the pupils and the teacher. These were collated to inform interpretations of the observed and documented impact of the intervention (Table 3)

**The nature of the intervention: A sequence of dramatised activities**

The activities comprising the intervention are summarised in Table 1. They began with the reading of a monologue entitled *Products from peanuts* (adapted from McGregor and Precious, 2015, p. 183). A teacher performed in role (as Teacher in Role, TiR) reading a reflective script (Figure 2) informed by the life of GWC. The perspective taken was that of him, deceased, reading his tomb-stone and reflecting on what he had achieved and how others may have benefitted from his work. His keen observational and recording abilities enabled him to investigate and improve agricultural practices in the deep south where cotton yields were, at that time, diminishing. His introduction of rotating different crops, including peanuts, that fixed nitrogen and increased soil nutrients available consequently improved the cotton crop output. Implementing this was no mean feat because the farmers, at that time, had no market for peanuts. The tenacity of this man, his experimentation and exploration of the uses of peanuts (such as oils, inks, cosmetics, glue…), generated economic interest in growing the crop. Astutely aware that he had developed and created unique procedures for making new foods, industrial and commercial products including flour, sugar, vinegar, ink, paint, glue etc from 'lowly' plants, GWC noted his techniques and processes carefully but 'in code' in order to retain his copyright.

Pupils are invited to learn more about GWC by 'hot seating' the teacher-in-role (Farmer, 2011, p. 28) (illustrated in Figure 2). Once orientated by the teacher's responses to their questions, the pupils worked together in small groups, to depict GWC's attributes as a scientist (Figure 3) in the form of a tableau (Farmer, 2011, p. 67) demonstrating the qualities he needed to succeed in his scientific endeavours. This immersed the pupils in the historical authentic context wherein the learning activities become more relatable and purposeful. Pupils then engaged with physically modelling (Farmer, 2011, p. 79) how plant growth was changed and affected by nutrient depletion (Figure 4) and the teacher provided additional contextual information, as required, about the focus of GWC's work.

To extend the opportunity for the pupils to work-in-role as young scientists, two experimental activities were presented for them to engage with. The first was growing radish seeds repeatedly in the same soil (Figure 5). The second was generating new products from plant material (Figures 6 i., ii., iii.). ~~The p~~Pupils' original thinking was evident in their outcomes and they demonstrated their creative thinking in quite unusual ways as they imagined and described new items produced from one plant product. For example, one small group of pupils, conceived many new products from a cantaloupe melon; such as paper, drink, using the skin as cups or bowls, making earrings from the necklaces and bracelets from the seeds, using the seeds to feed birds, drying the skin and seeds to make a gourd-type shaker and a stamp for a printing process, similar to potato prints.

**Table 1:** Summary of the GWC dramatised activities and pupil activity in relation to the the applied drama convention (adapted from McGregor & Precious, 2015).

| **Sequencing, and description, of GWC drama activities** | **Drama Convention** | **Pupil Activity** |
|---|---|---|
| **Activity 1:** GWC introducing himself, through the reminiscence of an old man, reading what it says on his tombstone and talking about his life as an agricultural scientist, who discovered how to grow particular plants in rotation to increase yield. | Listening to a monologue (Figure 2) | Observing and listening to the reflective story being told by their teacher (TiR) |
| **Activity 2:** Discussing the uses of different plant materials, so that nothing was wasted from a crop. | Hot Seating (Figure 4) | Questioning the TiR as an 'expert' about GWC, his work and the historical context in which he lived. |
| **Activity 3:** Highlighting the tenacity, determination, insight, application of knowledge, empathy with farmers plight and other attributes that GWC demonstrated in the way he conducted his life and work. | Tableau (Figure 3) | Depicting the various characteristics of GWC's life, work and scientific discoveries.<br><br>Acting as reflectors of GWCs life and work.<br><br>Depicting GWC's ability to draw, applying his detailed observation skills, study of plants and the structure of soil (Figure 6) |
| **Activity 4:** Enacting processes related to development of crop rotation that GWC proposed: | Modelling: Representing nitrogenous content of | Exploring the growth of plants over time, responding to sustained (remain healthy) or depleted (gradually wither and die) soil nutrients (Figure 5i) |

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|---|---|---|
| i. the impact of depletion of nutrients in soil<br>ii. replenishing nitrogenous content of soil | soil (Figures 5i and ii) | Exploring the growing of peanut plants when the nitrogen levels in soil is increased (Figure 5ii) |
| **Activity 5:** Inquiring in-role as GWC | Pupil working in role (WiR) as GWC (Figure 6); | Responding as a scientist and applying a scientific method. E.g.<br>i. Repeated trials: Growing radishes three times in the same soil.<br>ii. Inferring: Discussing, deliberating and exploring ways plant parts might be used to create or make something new and creative. |

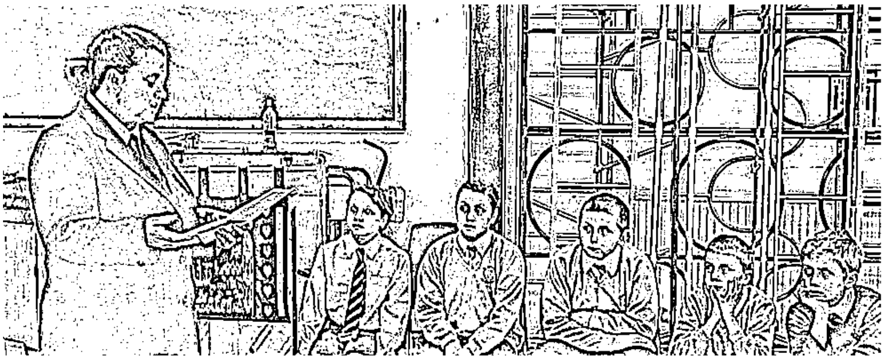

**Figure 2:** Illustration from the classroom of activity 1: Pupils listening to the teacher reading the George Washington Carver monologue.

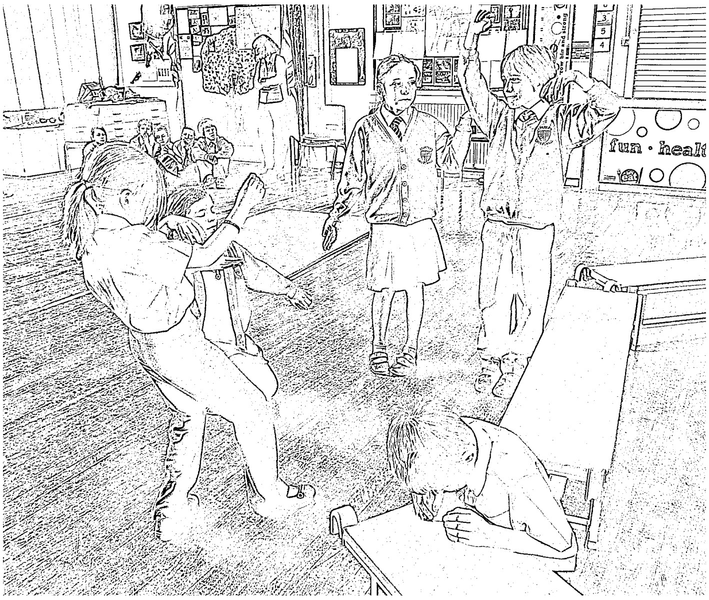

**Figure 3:** Illustration from the classroom of activity 3: Depicting the characteristics of George Washington Carver through the pupils enacting his attributes.

**Figure 4:** Illustration from the classroom of activity 2: Hot Seating the Teacher in Role (as GWC).

**Figure 5i:** Illustration from the classroom of activity 4: Modelling the beginning of the impact of depleted nitrogen on the growth of plants.

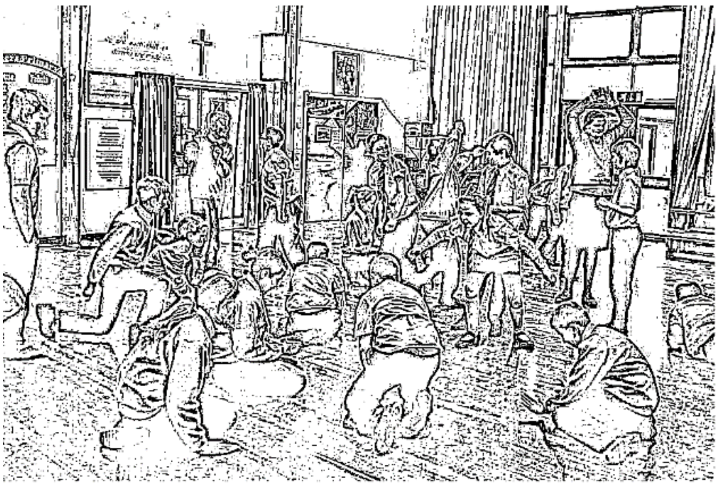

**Figure 5ii:** Illustration from the classroom of activity 4: Modelling the demise of more plants after repeated growing of the same crop in the same field.

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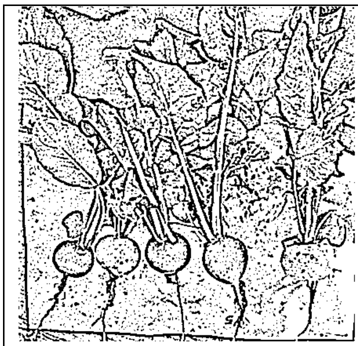
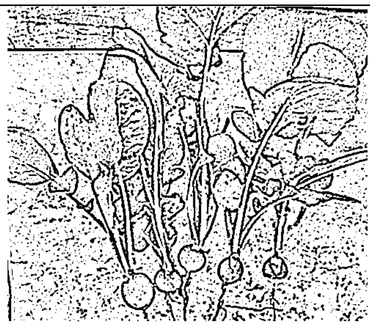
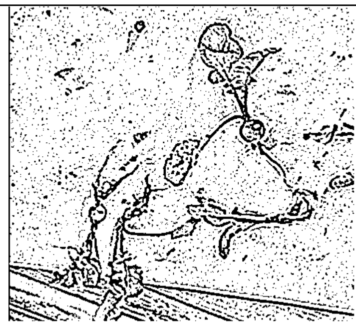
|  |  |  |
| 6i: First crop: Healthy range of radishes | 6ii: Second crop: Smaller radishes with less foliage | 6iii: Final crop: Very small, mis-shapen and mis-coloured radishes |

**Figure 6** i,ii,iii**:** Illustrations of impoverished growth of radishes three times over in the same soil.

**Findings**

Reflecting on the sequence of learning activities (Table 1), the teacher noted that the pupils' responded actively and creatively to the various drama conventions. Her reflective diary excerpts, as illustrated through quotations in Table 2 and 3, indicated that as a consequence of being introduced to GWC's story through a sequence of drama conventions, the pupils were, in her opinion, afforded invaluable insights into his working context. Their immersion into the activities reportedly opened new avenues for creative inquiry. Thus, developing the classroom as an imagined, 'as if', figured world (Rainio, 2008). The dramatised activities appeared to successfully enable pupils to better appreciate the nature of GWC's scientific achievements.

Creating a figured world in the classroom environment by adopting resources, artefacts and materials as well as designing activities that directly related to the narrative of GWC's life, characterised the imagined world of a black American born into slavery who became a prominent agricultural scientist. Pupils, sequentially, enacted different aspects of his life and work (as depicted in table 1). This enlivened pupils' participation in the creative teacher-generated figured world. In the case of GWC, there were many ways, as described in Table 2 and 3, that the teacher mediated their engagement in scientific practices (Osborne, 2014; McGregor et al., 2019) and their developing appreciation of the nature of STEM related inquiries.

**Table 2:** Indications of pupils creative thinking and scientific inquiry practices (adapted from Osborne, 2014) while engaged in different dramatic conventions.

| Indications of pupils’ creative thinking & scientific inquiry practices | Affordances offered within the dramatised activities | Quotations from pupils, and or their teacher, demonstrating their taking-up of the afforded opportunity |
|---|---|---|
| **Asking questions** | Having listened to the monologue, pupils inquired by asking questions of the teacher in role (TiR) as GWC (Figure 2) | “Some people seem to think that the history of it is kind of pointless [...] if you can figure out what their thought-process was maybe you could do something similar. Or at least if you can't do something similar you can kind of better understand where it comes from. I guess it just helps you to see from their perspective.” Joe: Pupil reflection |
| **Constructing explanations** | Pupils were thinking creatively and proposing explanations from observations about what happens to plants when nutrients are depleted. | “We modelled being trees and put counters on the floor to represent water, nutrients and light. Each tree had to get what it needed to grow healthily, those that didn’t ended up withering and dying.” Chloe: Interview |
| **Engaging in argument from evidence** | Pupils were considering observations, and thinking like scientists about different forms of evidence. | “I really like that [..] the creativeness [….] it was really interesting, I think it gets you in the right frame of mind actually creating stuff is I guess that's what science actually is.” Joe: Interview |
| **Planning and carrying out investigations** | Pupils were positioned as scientists as they planned conducted and reviewed outcomes of experiments. | “It was lovely that it was practical and hands-on. I know better how to plan my experiments in class now.” Phoebe: Interview |
| **Analysing and interpreting data** | Pupils reflected and inferred as they reviewed outcomes of the repeated trials (x3) of radish seeds grown in the same soil (Figures 6i, 6ii, 6iii). | “I guess if you understand where the original scientists happened upon it, I guess it helps you recreate that he saw what they went through and then if you do a similar technique, you kind of figure out it's like. If you don't know how they found out there's no way that you're going to. Maybe the way they came across it is the best way to learn it.” |

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| | | Joe: Interview |
| **Using mathematical and computational thinking** | Pupils dialogically exchanged ideas, tested their methods and developed creative solutions, positioning themselves as scientists. | "The children discussed their ideas about how they worked as scientists testing their own theories." Teacher: Reflective field notes |
| **Obtaining, evaluating and communicating information** | Pupils communicated how they investigated and found solutions when they explained what they did to the teacher and their peers. | "It's great to find out about things I do not understand and using drama helps me learn better in science." Madison: Interview |

The pupils' reflections, as highlighted by their quotations in Table 2, on ways that the intervention impacted on their understanding of science and inquiry, are corroborated and complemented by the teacher's perspectives of the impact on the class in general. The teacher's reflections (Table 3) on the impact of the action research project, confirmed how it was possible to scaffold and mediate pupils engagement with STEM inquiries, by employing drama conventions, and generating an 'as if' world that created a reconfigured and deeply contextualised classroom experience.

**Table 3:** Teacher's reflections: The impact of the intervention on pupils' creative STEM-inquiry

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| **Inquiry ideas and evidence** | "Generating ideas by using drama techniques, such as the stories of scientists via dramatic monologues does stimulate great ideas in learners. It helps them to *stand in the shoes* of scientists, understand their difficulties and unique ways of working, thus helping them to assume a role of [a historical] scientist themselves. Looking at evidence from the past, modelling ideas with their bodies (such as the uptake/replenishment of nitrogen in soil by cotton/peanuts) and learning about scientific endeavour, sites their own learning in realistic scientific contexts. They find this engaging and enjoyable and it provokes much discussion and dialogue as they construct their own ideas and ways of working based on a historical figure". |
| **Planning an experiment** | "Pupils have described understanding how a scientist studied and worked themselves, is key in their approach to designing an experiment. With the GWC story, the fact that he came up with 300+ uses for a peanut inspired the children to *think outside the box*. If he could develop so many uses for one product, they too could do that. Discursive approaches helped the children to not only discuss, but also develop new approaches to planning their |

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| | experiments modelling their ways of working on their perceptions of his scientific process and making sense of seemingly complex processes into their own more simple ones". |
| **Obtaining and presenting evidence** | "The children had to *sell* their uses for their product, as GWC pioneered, taking a mobile classroom (on a *Jessop wagon*) to bring his ideas to farmers. Children enjoyed this engaging way of presenting their results and evidence to others. They engaged in good questioning of each other in the process". |
| **Considering evidence and evaluating** | "Evaluating their learning from these immersive tasks, children wrote very enriched learning comments in their science books". |

**Discussion**

This chapter has been written to consider, 'How can a dramatised inquiry, informed by GWC's historical story, support pupils' STEM learning?' Within a traditional classroom context, pupils engaged with a STEM activity are unlikely to produce the kinds of cultural and revolutionary innovations that renowned scientists like Newton, Einstein, Curie or Dunlop have produced. However, as McGregor (2016), McGregor et al. (2019), Swanson (2016) and Stagg (2020) demonstrate, by using drama techniques to create alternate contexts, young learners (aged ten and eleven years old) can work-in-role as a scientist, construct understandings about the nature of science and act agentively in the ways they consider what could be done about problems posed.

The 20 divergent ideas, for example, suggesting alternate ways a cantaloupe melon could be used, was produced by one group of children from the class of 30 pupils. This resonates with GWC's innovative thinking, developing over 300 uses for the peanut. This activity illustrates Craft's (2001) everyday 'little-c' creativity as the pupils actively engaged in 'possibility thinking'. Runco (2003, p. 318) suggests how this type of everyday problem solving is linked to "… the construction of new meaning". These are arguably new "mental combinations that are expressed in the world" (Sawyer, 2012, p. 7) which are original to the creator [the pupil]. However, witnesses to this form of creativity (i.e. the teacher and peer group) are needed to verify pupils recognising their own expression of personal creativity, and innovative contribution to class thinking.

All four strands of creativity that Murcia et al. (2020) outline: Person, Place, Process and Product; were evident within this project. For example, the *Person*, the educator was creative in the way she generated the configured world of GWC and the ideas generated by the pupils were also original; the *Place*, the 'as-if' figured world provided an imagined environment for creative inquiry; the *Process*, the engagement in various tasks scaffolded and mediated learners' development of creativity as they designed, reviewed and conducted their inquiries and finally the *Product,* the outcomes from both planting radish seeds in re-used, depleted soil and the innovative creativity in suggesting multiple ways that different plant parts could be used to create new products.

**Conclusion**

Reflecting on the success of this project, the evidence suggested that the creative teaching was engaging, imaginative and highly original, and supported the emergence of learner creativity. There were a variety of ways that affordances were extended to generate the kind of classroom environment that promoted the development of the pupils' ingenuity, innovative thinking and agentive actions (Bruner, 1996). Elements of creative practice were clearly demonstrated in this project. A range of features supported pupil activity and development as young scientists, including how the teacher encouraged pupils to "question and challenge, make connections and see relationships, speculate, keep options open while pursuing a line of enquiry, and reflect critically on ideas, actions and results" (Ofsted, 2010, pp. 5-6), all actions demonstrating creativity in their inquiry practices. Whilst these are all qualities demonstrated by scientists, as suggested by McGregor and Frodsham (2019), simply acknowledging that these are desirable features, is not sufficient to pedagogically support the development of pupils' scientific creativity. Educators need help in recognising how to support learner creativity in various multifactated ways.

The adoption of a socio-cultural lens, highlighted how the creative teaching approach shared in this chapter, offered at least seven learning affordances that extended pupils' creative inquiry learning trajectories in STEM contexts:

i. immersing into a historical context which related to a scientist's life and work, through adopting an '*as if*' figured world
ii. providing *artefacts* that resonate with the '*as if*' world and related directly to the presented learning tasks
iii. extending *accessible* tasks and affording authenticity for the pupils to work-in-role
iv. inviting pupils to *act* as scientists-in-role as they engaged in participatory activities
v. enabling pupils to decide upon *actions* that are appropriate to undertake within the figured world of a scientist
vi. encouraging pupils to work with others, forming *alliances*, and collaborating to resolve problems
vii. celebrating the *artistic* and resourceful outcomes of the dramatized activities

In summary, this chapter synthesised evidence from an action research project and explored the affordances offered by dramatic inquiry for promoting pupils' creativity in STEM. Scrutiny of the evidence suggested that dramatised activities extended affordances for learners beyond the 5A's identified by Glăveanu (2020). The creative teaching intervention enabled pupils' to explore a scientific context that was historically imbued, and deeply engaged them in thinking and acting in informed ways within the STEM inquiry contexts. We aimed to illustrate through the presentation of the GWC activity series how adopting a socio-culturally informed approach and creating an imaginary 'as-if' figured world characterised by a real story of a scientist and his work from a historical perspective, successfully engaged pupils in inquiry and inquiry related activities. Analysing the impact of this approach by adopting mixed methods, provided rich and converging evidence of the many and varied ways inquiry learning, supported through the adoption of drama conventions, create an imaginary scientific world that could be described as containing elements of an enabling environment (Murcia et.al., 2020).Therefore, adopting the framing of a figured world, constructed through the application of a series of immersive drama conventions, extended learning affordances, supported inquiry practices and enabled young pupils to creatively solve authentic STEM problems.

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