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History and Philosophy in Science Teaching: The Perspective of Artisans in Scientific Discovery Using Drama as Inclusion

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Abstract

Historical episodes in scientific discovery provide excellent sources for integrating the Nature of Science and personal contributions that can be motivating and engaging ([1] HIPST, n.d., [2] Höttecke, 2012). There are two levels of questions:

1. *What information is available to support the construction of authentic learning experiences that integrate historical events and the Nature of Scientific Discovery?*
2. *What method can be used to give voice to those who are not known about or forgotten in a historical event?*

The episode chosen was the construction of the laboratory in the 1770s of Marie and Antoine Lavoisier and, in particular, a piece of equipment for handling water-soluble gases in enquiries about their chemical properties. The equipment was a large box, on legs, containing a shelf. Mercury was the liquid chosen for containing such gases. Antoine Lavoisier was, undoubtedly, highly accomplished as tax accountant, and in chemical enquiry. Marie Lavoisier was a remarkable illustrator, an excellent translator, and later, in chemical enquiry. However, it seems they needed to call upon the services of artisans to construct the laboratory. There are many valuable sources of evidence about these two and about the social issues during the French Revolution.

The essential and expert role of artisans in the construction of the laboratory has not been recorded, yet must have been important, given the limitations of craft knowledge of the Lavoisiers. In the spirit of giving these unknown artisans a place in the collaborative discovery process, I have used artistic licence, informed by evidence of their work at the time, to construct a fictional drama from the perspective of the two artisans involved, a carpenter and a stonemason, to produce a pneumatic trough to contain mercury for the subsequent experiments.

Additionally, the drama places in parallel historical information on The French Revolution, scientific discovery of the time, and ideas that were being created (philosophy). The paper also proposes a pedagogy for its use that engages all of the learners.

Introduction

Braund (2015) [3] stated 'Constructivist teaching methods such as using drama have been promoted as productive ways of learning, especially in science. Specifically, role plays, using given roles or simulated and improvised enactments, are claimed to improve learning of concepts, understanding the nature of science and appreciation of science's relationship with society (Ødegaard, 2001 [4]). So far, theorisation of drama in learning, at least in science, has been lacking and no attempt has been made to integrate drama theory in science education with that of theatre. [Braund's] … article draws on Brook's (1968) notion of the theatre as the '*empty space*' to provide a new theoretical model acting as a lens through which drama activities used to teach science can be better understood and researched. There are many other similar articles concerning the contribution of drama to science education. The scenarios adopted directly pertinent to science education are twofold: a) dramatic models such as using students to model particle movement in different phases; b) historical narratives of eminent sciences, often to illustrate the nature of science. It is relatively rare, if at all, to read accounts of the contribution of those other than eminent scientists who have made their contribution to scientific discovery. Since their accounts are not recorded it is although they did not exist. Nevertheless, despite the prodigious output of eminent scientists, it must be the case that they depended on the valuable inputs of artisans of significance. Dramatic licence afforded by the construction of plays provides opportunities to imagine what these inputs could have been, without necessarily implying historical accuracy. This paper provides an example of an input that is plausible and credible, involving a carpenter and a stonemason.

In addition to concept development, drama can impact on student attitude (e.g. Hendrix *et al*, 2012). Drama can also contribute to historical and philosophical understanding (see HIPST [1]).

'HIPST pursues general objectives: a better integration of science in society and society in science, the promotion of young people's interest in science, to encourage their critical and creative ways of thinking and to improve science education, and the uptake of scientific careers. Sustained learning of science implies many different dimensions. One often ignored, but important dimension is the process of knowledge generation in science itself. Moreover, the objectives and motivations to do science, the disposition of scientific skills and methods, the empirical fundament of science, social and cultural aspects are as important as philosophical foundations of science, scientific concepts and their use. The acquisition of knowledge about the nature of science is essential for democratic and knowledge based societies which partly rest their decision making on rational and scientific criteria.'
The HIPST project in the UK used, as one of its tools, drama to focus on historical and philosophical aspects. The HIPST web site provides details of the challenges and successes of drama, especially the challenge of 'whiggishness', looking at the past through the knowledge lens of the present, leading to misunderstandings of historical knowledge development.
The carpenter and the stonemason: their contribution to 18th century chemistry discovery.

Actors

Jacques Cabinet: an expert cabinet-maker who provided wooden components for the Lavoisier Laboratory. He was a permanent employee of the Lavoisier family and a trusted artisan.
Robert Graves: an expert stone-mason who constructed cemetery headstones and marble coffins,
Marie Lavoisier: wife of Antoine, an expert translator French-English, and eventually a chemist of some significance, having been taught by one of Antoine's students
Antoine Lavoisier: husband of Marie, tax collector, eminent chemistry researcher and government expert in matters such as gunpowder quality

Selected history of the time	History of Science	Philosophy (Nature of Science)	Commentary
The environment of the 18th century was one of political revolution. In France, the excesses of the King and the poverty of the most of the people, with widespread starvation and disease were major causes of the French Revolution. Peoples' Courts were set up and being found guilty usually led to immediate execution. The King had set up the General Farms where taxes were sold to these Farms at a discount, who then did their best to collect the full taxes, usually making a big profit through violence. There were many wars over power and land for national leaders, especially Kings. Great Britain came into existence in 1707 and more people were able to read. Slavery was common.	1703 Isaac Newton elected President of the Royal Society 1710 Porcelain factory in Meissen, Saxony, founded 1714 DG Fahrenheit constructs mercury thermometer 1730 Réaumour constructs alcohol thermometer 1751 British Calendar adopts January 1st as beginning of New Year 1789 French revolution starts 1792 Louis XV guillotined in Paris	The nature of stuff is explored in this century. In particular chemists were interested in whether something was a single material (an element) or a combination of elements. Scientific journals were developing. Much news came out in books 1734 The Koran was translated into English by George Sale	This play is set in the 1780s in the home of husband Antoine-Laurent Lavoisier and wife Marie-Anne-Pierrette Paulze. A century before Marie Curie made a place for women in theoretical science, editor, translator, and illustrator Marie (1758-1836) was wife and research partner of chemist Antoine. She also became one of chemistry's first female researchers. she cultivated the arts and welcomed intellectuals for stimulating conversation.
The Drama			

Jacques Cabinet Good morning Monsieur and Madame Lavoisier. How can help today? I have finished the shelves, as you can see. I have only to paint them with the varnish you gave me. This should make sure they are not attacked by chemical gases you use!	Antione was a rich man, with much money made from running a Tax Farm. Their house had a large and well-equipped Laboratory, with hand-made equipment. The wooden equipment was made by Jacques. He could only work in wood,	Antoine and Marie were fascinated by gases. Thanks to Marie's skills in translation, they were both familiar with international discoveries. With this knowledge, they could hope to make their contributions to the chemistry of gases.	Jacques is no ordinary artisan. He has been closely involved with the work of the Antoine and Marie. He was expected to understand their requirements to construct what they wanted
Marie Lavoisier Good morning Jacques. We have need for a container that can contain mercury to trap the gases. It will need a shelf to one side, on which to stand the upside down jars which will contain the gases.	Artisans were sometimes treated as part of the family. Respect for the husband and wife, though, would always continue.		Marie had learned English to translate papers for Antoine, and she had learned chemistry from one of his students. She was also a superb illustrator.
Antoine Lavoisier Jacques, please make the container from the best wood you can buy. It must be strong, with no holes through which the mercury liquid can leak out. I recommend you use a very strong joint, some as dovetail. Please varnish it to stop the mercury leaking through.	Porcelain might have been a better material to use but at this stage of development, it was being used mainly for fine dining ware.	Making porcelain is not easy.	Although they were no expert artisans, Antoine and Marie knew enough about wood to think of some of the problems that could arise.
Jacques Cabinet (next day) The mercury has leaked out. I think I can explain this. The wood has shrunk. This then opens the joints letting out. I have another idea	,		Jacques is the expert here. He is trusted by Antoine and Marie to find the best explanation.
Jacques Cabinet (next day) Let me introduce my friend, Robert Graves. He is a stone mason. He may be able to help.			

Robert Graves I can use a whole block of marble, which I then carve out from the inside, to make a kind of box. I have the skills to choose the best marble so that it can stand the force of mercury without cracking.			Stone masons were experts in handling stone
Antoine Lavoisier (next day) Robert, it is indeed, an excellent design. Your craftsmanship is superb. We are very impressed. It looks as though it will last a lifetime. Jacques, it is very lucky for us that you found Robert. We really did need this piece of equipment. Without it, we cannot make our discoveries. Marie and I are agreed on this.			

Pedagogy

We are greatly influenced by our experiences as adults, especially in areas of pedagogy which are unfamiliar. Most of our experiences of drama is gained by attending plays, where professional or experienced amateurs put on a performance, **in front of** an audience, who have often paid to watch. Much of the experience is passive for the audience. With young learners, they are not professional or experienced amateurs. In a single class, there will be a range of confidence. In addition, I believe it is significant and beneficial for learning if the young learners can be involved. I also believe that a major contribution to learning can come from the discussions that follow from the drama. It is an advantage for the play to be relatively short, since it is possible for it to be repeated without using up too much class time. Here is a proposed pedagogical sequence:

1. Copy the play for each class member, in the form of four columns. The context of the play is just as important as the dialogue.
2. Ask the young learners to read the play, and the context, for homework, to prepare for the next lesson.
3. At the next lesson, divide the class into groups of 4 – 6. The groups allocate members to take on roles, or to be the audience. For the performances, it may be helpful if the actors face the walls so that they are not speaking at the other groups.
4. I suggest that they repeat the play with the roles changed. This will give them an insight into different perspectives.
5. After they have performed the play (one, two or three times), they discuss what they have learned.
6. The teacher, who has been listening, draws the points about learning together.

Conclusion

This paper has integrated history of chemistry, evidence concerning the roles of drama in science education, ideas about social justice, and an engaging pedagogy. Hendrix *et al* (2012) [5] attest to the value of drama on motivation.

Implications

Engaging young learners in their own learning is a challenge many teachers face. This paper describes one method of doing this.

References

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