Drama for inclusion in science: recognising the role of artisan input

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Science Education Futures

Abstract

Drama is used to present history and philosophy of chemical discovery, recognising artisan input. 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. Nevertheless, 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. **Context of the drama**: Drawings of Lavoisier's laboratory provide many indications that it was not the work of one person, given its complexity. Lavoisier required a pneumatic trough to contain the gases he worked with, using mercury as the containing liquid since many of the gases were soluble in water. It contained a shelf, usually immersed, on which to stand the jars upside-down. Lavoisier invited an artisan (carpenter) to build a trough from wood and filled it with mercury. In the morning, he found that the mercury had leaked out during the night as the wood contracted opening up the joints. He found another artisan (a stonemason) to make one from marble, and this did the trick. The play tells the story from the point of view of the carpenter, and incorporates history and philosophy into its telling. The paper provides pedagogical advice on use in classes aged 11-14 years old. **Conclusion**: The paper will provide evidence of its success based on pupil feedback and project documentation.

Keywords: Drama; chemical discovery; artisans; craft knowledge; social justice; history and philosophy of science

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Introduction

Braund (2015) 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). 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 as though 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: http://hipst.eled.auth.gr/).

'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 (detailed at http://hipst.eled.auth.gr/) 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.

Context of the drama

Drawings of Lavoisier's laboratory provide many indications that it was not the work of one person, given its complexity. The Chemical Revolution of the late 18th century was based in large part on Antoine-Laurent Lavoisier's new understanding of the chemical role of a gas — oxygen— in explaining combustion, respiration, and metallurgical processes like smelting. This advance in the theory of material change drew upon earlier work by other chemists, such as Joseph Priestley, who demonstrated that the air we breathe, previously thought to be uniform and not a kind of matter like solids or liquids, is in fact made up of several gases with different properties. Lavoisier's successors further explored the character of gases. Their theoretical advances eventually proved of great importance to modern society: many industrial processes require gases and their compounds and rely on a thorough understanding of the reactions that produce them. Lavoisier required a pneumatic trough to contain the gases he worked with, using mercury as the containing liquid since many of the gases were soluble in water. Priestley's trough is shown in the diagram below. It contained a shelf, usually immersed, on which to stand the jars upside-down. Gases do not have an innate volume but only when trapped by the faces of solids or liquids. Lavoisier invited an artisan (carpenter) to build a trough from wood and filled it with mercury. In the morning, he found that the mercury had leaked out during the night as the wood contracted opening up the joints. He found another artisan (a stonemason) to make one from marble, and this did the trick. The play tells the story from the point of view of the carpenter, and incorporates history and philosophy into its telling.

The drama *The carpenter and the stonemason: their contribution to 18th century chemistry discovery*

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, marble coffins, and carved ornate stone furniture for the outside of buildings such as churches. He was not a permanent employee but did work from time to time on special projects

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.

Table1: Relevant Background To Context of The Drama, Followed By The Drama

Selected history of the time	History of Science	Related 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. There are 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 is common. 1751 British Calendar adopts January 1st as beginning of New Year 1760 Josiah Wedgwood founds pottery works in Etruria, Staffordshire 1771 R Arkwright produces first spinning mill in England 1787 Dollar currency introduced. 1789 French revolution starts 1792 Louis XV guillotined in Paris	1703 Isaac Newton elected President of the Royal Society 1710 Jakob Le Blon invents three colour printing 1710 Porcelain factory in Meissen, Saxony, founded 1714 D Anel invents fine-pointed syringe 1714 DG Fahrenheit constructs mercury thermometer 1717 Inoculation against smallpox by Lady Montagu 1730 Réaumour constructs alcohol thermometer 1734 The Koran was translated into English by George Sale 1732 Boerhaave writes 'Élements of Chemistry', a textbook 1736 Manufacture of glass begins in Venice 1742 Anders Celsius invents centigrade thermometer 1754 Joseph Black discovers carbonic acid gas (carbon dioxide) 1761 M Lomonosov discovers atmosphere of Venus 1766 Cavendish: hydrogen is less dense than air 1772 D Rutherford and J Priestley independently discover nitrogen 1774 KW Scheele discovers chlorine 1777 A Lavoisier: air is mainly nitrogen and oxygen 1787 Lavoisier writes 'Méthode de nomenclature chimique.' 1790 A Lavoisier writes 'Table of thirty-one chemical elements' 1794 A Lavoisier guillotined 1795 Metric system adopted in France	The nature of stuff is explored in this century. In particular chemists were interested in whether a material was a single material (an element) or a combination of elements. The idea of publishing discoveries in scientific journals was developing. Much news came out in books, or in discussions at the newly formed Scientific Academies, which were springing up in the 18th century.	This play is set in the 1780s in the home of husband Antoine-Laurent Lavoisier and wife Marie-AnnePierrette Paulze. A century before Marie Curie made a place for women in theoretical science, editor, translator, and illustrator Marie Paulze Lavoisier (1758-1836), wife and research partner of chemist Antoine Laurent Lavoisier, surrounded herself with laboratory work. As assistant and colleague of her husband, she became one of chemistry's first female researchers. In addition, she cultivated the arts and welcomed intellectuals to her Paris salon for stimulating conversation. After her husband's execution she unhappily married Benjamin Thompson, Count Rumford, the American-Bavarian military adviser, and founder of the Royal Institution of Great Britain.

The Drama			
Scene 1: in the Lavoisier Laboratory. Present: Monsieur Jacques Cabinet, Monsieur Antoine Lavoisier, Madame Marie Lavoisier			
Dialogue	**Relevant history**	**Relevant science and philosophy**	**Commentary**
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. Although he and Marie had no children, their wealth had given them much comfortable living, and a fine house. The house was big enough to have a large and well-equipped Laboratory, with hand-made equipment. The wooden equipment would have been made especially for the job by Jacques. He could make large equipment, as well as very fine small scale items. He could only work in wood, though, but he had many artisan friends he could call on.	Antoine and Marie were fascinated by gases. Thanks to Marie's skills in translation, they were both familiar with discoveries, and how other chemists had learned how to trap gases and then investigate their behaviour. Without this, they could not 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 with only a little explanation, and to use his combined expertise and creativity to construct what they wanted.
Marie Lavoisier Good morning Jacques. As you know, 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. It needs to have a table next to it for the gas manufacture equipment. It should also be easy to move it near to the furnace, in case strong heat is needed.	Artisans were sometimes treated as part of the family. Respect for the husband and wife, though, would always continue.	Antoine and Marie were keen to study the interactions between the gases they made.	Marie is no passive wife. She had learned English to translate papers for Antoine, and she had learned chemistry from one of his students. She is also a superb illustrator.
Antoine Lavoisier Jacques, please make the container from the best wood you can buy. It must be strong, with no knots that can be pushed out, or holes through which the mercury liquid we will use 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, such as plates, cups and saucers.	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.
Antoine Lavoisier Jacques, please make the container from the best wood you can buy. It must be strong, with no knots that can be pushed out, or holes through which the mercury liquid we will use can leak out. I recommend you use a very strong joint, some as dovetail. Please varnish it to stop the mercury leaking through.			Although they were no expert artisans, Antoine and Marie knew enough about wood to think of some of the problems that could arise.
Three days later, back in the Laboratory. Present: Monsieur Jacques Cabinet, Monsieur Antoine Lavoisier, Madame Marie Lavoisier			
Marie Lavoisier Jacques, show us what you have made, and talk us through it.			Marie is something of an expert in her own right.

Jacques Cabinet You have room in the laboratory to make a good size container. I made this from the best Rosewood I could find, sawn by the best sawyers into planks. I used large planks 2 feet wide for the sides and the edges, and dovetailed to make very strong joints. You will see that I have only used a single piece of wood for the container bottom. I have used the best wood glue I could buy. The shelf is freely moving, and made in a similar way. I have cut a hole in the side, and on the top. This should allow the clay pipe to be fed in so that the gas will bubble up into the jar, filled with mercury and placed upside down.		Rubber tubing for a gas delivery tube was not available at this time. Often clay tubing was used, as this was known through clay pipes that were used for smoking tobacco. It was easier to use than glass at this stage of chemistry.	
Antoine Lavoiser A good job, I think Jacques. It will need a lot of mercury to fill it. The mercury is in these pots here. Will you help me to lift them and fill the container, please? Then we can start our practical investigations tomorrow.		The mercury was stored in earthenware pots as these were commonly available. They were glazed on the outside to stop the mercury leaking out.	
The next day, back in the Laboratory. Present: Monsieur Jacques Cabinet, Monsieur Antoine Lavoisier, Madame Marie Lavoisier			
Jacques Cabinet Oh dear! I thought this might happen. The mercury had leaked out.			
Marie Lavoisier I cannot see how this would happen. You used the best wood, the best joints, and the best glue. Also, you varnished it very well. What do you think happened Jacques?			Marie tries her best to explain. Here her knowledge of wood is not enough. Jacques is a well-known member of the community of artisans, and can find good advice and help from many of these knowledgeable friends.
Jacques Cabinet I think I can explain this. You usually have the furnace on during the day. At night, the temperature drops and the room air becomes drier. I think this makes the wood shrink. This then opens the joints enough for the mercury to leak out. I do not think that using wood can solve this problem. I have a friend who may be able to help. See me here tomorrow, please. See if you can someone to take up the mercury. We can use it again.			Jacques is the expert here. He is trusted by Antoine and Marie to find the best explanation. In addition,
The next day, back in the Laboratory. Present: Monsieur Jacques Cabinet, Monsieur Antoine Lavoisier, Madame Marie Lavoisier, and joined by a stone mason Robert Graves			
Jacques Cabinet Good morning Monsieur and Madame. Let me introduce my friend, Robert Graves. He is a stone mason. He may be able to help.			
Marie and Antoine Lavoisier (together) Please to meet you Robert. What idea do you have?			

Robert Graves It is an honour to meet you, too. Sometimes, I am asked to make a coffin which is impermeable, that is, water and creatures in the ground outside cannot get in. I use whole piece of marble, which I then carve out from the inside, to make a kind of box. It needs to be done very carefully to make sure it is very strong. I have the skills to choose the best block of marble from the stonecutter, so that it can stand the force of mercury without cracking. Shall I get to work, now? I will work inside the Laboratory since the marble is heavy. Once I start work on it, I do not wish to drop it. Where do you wish it to sit?			Stone masons were experts in handling stone in many different ways.
The next week, back in the Laboratory. Present: Monsieur Jacques Cabinet, Monsieur Antoine Lavoisier, Madame Marie Lavoisier			
Robert Graves You will see that the container is finished now. I filled it with mercury yesterday, with my apprentice. What do you think?	Artisans rarely worked alone, and the apprenticeship process was very strong.		
Antoine Lavoisier 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 Lavoisier So now we see that it is not enough to be an expert in chemistry. We need to work together with expert artisans to carry on our work. Without you we could not have made our discoveries.			Marie realises the points that chemists and artisans must work together to make discoveries. Sadly, the artisan input is rarely recorded.

So, the community of scientists and artisans continue their joint work in the interests of scientific discover!

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

The paper provides an integrated approach to using historical evidence combined with plausible fictional dialogue to promote promotion of the contributions of artisans in the process of scientific discovery.

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