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DRAMA FOR INCLUSION IN SCIENCE

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Abstract: 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. Drama can also contribute to historical and philosophical understanding. This paper has integrated history of chemistry, evidence concerning the roles of drama in science education, ideas about social justice, and an engaging pedagogy. A next stage is to see how this works with different classes, and with different contexts for the plays and their histories. Engaging young learners in their own learning is a challenge many teachers face. This paper describes one method of doing this.

Keyword: Drama, science

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 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: 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.'

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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.

Drawings of Lavoisier's laboratory (see below) 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 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, 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 studentsAntoine Lavoisier: husband of Marie, tax collector, eminent chemistry researcher and government expert in matters such as gunpowder quality.

Selected	History of Science	Related philosophy	Commentary
the time		(Nature of Science)	
The	1703 Isaac Newton	The nature of stuff is	This play is
environmen	elected President of the	explored in this century. In	set in the
t of the 18 th	Royal Society	particular chemists were	1780s in the
century was	1710 Jakob Le Blon	interested in whether a	home of
one of	invents three colour	material was a single	husband
political	printing	material (an element) or a	Antoine-
revolution.	1710 Porcelain factory	combination of elements.	Laurent
In France,	in Meissen, Saxony,	The idea of publishing	Lavoisier and
the excesses	founded	discoveries in scientific	wife Marie-
of the King	1714 D Anel invents	journals was developing.	Anne-Pierrette
and the	fine-pointed syringe	Much news came out in	Paulze. See
poverty of	1714 DG Fahrenheit	books, or in discussions at	http://www.m
the most of	constructs mercury	the newly formed Scientific	etmuseum.org/
the people,	thermometer	Academies, which were	toah/works-of-
with	1717 Inoculation	springing up in the 18 th	art/1977.10 for
widespread	against smallpox by	century.	a Jacques
starvation	Lady Montagu	1734 The Koran was	David portrait
and disease	1726 S Hales measures	translated into English by	of the couple.
were major	blood pressure	George Sale	A century
causes of	1730 Réaumour		before Marie
the French	constructs alcohol		Curie made a
Revolution.	thermometer		place for
Peoples'	1732 Boerhaave writes		women in
Courts were	'Élements of		theoretical
set up and	Chemistry', a textbook		science,

being found	1736 Manufacture of	editor,
guilty	glass begins in Venice	translator, and
usually led	1742 Anders Celsius	illustrator
to	invents centigrade	Marie Paulze
immediate	thermometer	Lavoisier
execution	1748 Platinum comes	(1758-1836)
The King	to Europe from South	wife and
had set up	A merica	research
the General	1754 Joseph Black	nartner of
Earms	discovers carbonic acid	chemist
Where taxes	gas (carbon dioxide)	Antoine
where sold to	1761 M Lomonosov	Laurant
these Forms	discovers etmosphere	Laurent
these rains	of Vonus	Lavoisier,
di a	1766 Covendish:	horeolf with
uiscouiit,	1700 Cavendisii.	laboratory
did their	then air	laboratory
did their	than air	WORK. AS
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usually	nitrogen	sne became
making a	1//4 KW Scheele	one or
big profit	discovers chlorine	chemistry's
accompanie	1/// A Lavoisier: air is	first female
d by	mainly nitrogen and	researchers. In
violence	oxygen	addition, she
towards	1/8/ Lavoisier writes	cultivated the
those who	'Méthode de	arts and
would not	nomenclature	welcomed
or could not	chimique.	intellectuals to
pay. In	1790 A Lavoisier	her Paris salon
England,	writes Table of thirty-	for stimulating
the	one chemical elements'	conversation.
revolution	1794 A Lavoisier	
was not	guillotined	After her
quite as	1795 Metric system	husband's
violent and	adopted in France	execution she
centred		unhappily
round the		married
new		Benjamin
Protestant		Thompson,
religions.		Count
Many		Rumford, the
religious		American-
ministers		Bavarian
were very		military
strong in		adviser, and
their views,		founder of the
and gave		Royal
very		Institution of
controversi		Great Britain
al sermons		Read more at
to their		http://biograph
congregatio		y.yourdictiona
ns. This		ry.com/marie-
often made		paulze-
their		lavoisier#eud1
congregatio		<u>zQuj4HQ1mG</u>
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angry.		
Joseph		Oxygen by
Priestley,		Carl Djerassi
for		and Roald

avamala		Hoffmann ia
example,		Holimann is
was		one play that
attacked at		18
his house in		fictionalised,
Birmingha		with
m and		conversations
forced to		between
flee to		chemists'
London for		wives in the
safety		sauna
There are		sauna.
monu word		
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		
edents		
January 1 st		
January 1		
beginning		
of New		
Year		
1752		
Britain		
adopts		
Gregorian		
Calendar by		
leaving out		
3-13		
September.		
1760 Josiah		
Wedgwood		
founds		
potterv		
works in		
Etruria		
Staffordshir		
C 1771 D		
1//1K		
Arkwright		
produces		
first		
spinning		
mill in		
England		
1787 Dollar		
currency		
introduced.		

1789 French revolution starts 1792 Louis XV guillotined in Paris		The dra	ama			
Scene 1: in the Antoine Lavoi	Scene 1: in the Lavoisier Laboratory. Present: Monsieur Jacques Cabinet, Monsieur Antoine Lavoisier, Madame Marie Lavoisier					
Di	ialogue	Relev	Relevant history Relevant science and philosophy		Commentary	
Jacques Cabin Good morning Madame Lavo today? I have f shelves, as you only to paint th varnish you ga make sure they by chemical ga	net Monsieur and isier. How can help finished the a can see. I have hem with the we me. This should y are not attacked ases you use!	Antione w with much from runn Farm. Alt Marie had their weat them much living, an The house enough to and well- Laborator made equi wooden e would hav especially Jacques. I large equi as very fini items. He work in w but he had friends he	vas a rich man, h money made ning a Tax hough he and d no children, th had given ch comfortable d a fine house. e was big b have a large equipped cy, with hand- ipment. The quipment ve been made y for the job by He could make ipment, as well ne small scale could only yood, though, d many artisan e could call on.	Antoine were fa gases. T Marie's translat both fai discove other ch learned gases an investig behavio this, the hope to contribu	e and Marie scinated by Thanks to s skills in ion, they were miliar with rries, and how nemists had how to trap nd then gate their our. Without ey could not make their ations to the try 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 Lavoisi Good morning know, we have container that of mercury to trap need a shelf to to stand the up which will com needs to have a the gas manufa It should also b near to the furn heat is needed.	er g Jacques. As you e need for a can contain p the gases. It will o one side, on which oside down jars tain the gases. It a table next to it for acture equipment. be easy to move it nace, in case strong	Artisans v treated as family. R husband a though, w continue.	were sometimes part of the espect for the and wife, yould always	Antoine were ke interact the gase	e and Marie een to study the ions between es 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 Lavoi Jacques, please container from can buy. It mu no knots that c or holes throug mercury liquid leak out. I reco very strong joi dovetail. Pleas	e make the e make the the best wood you st be strong, with ean be pushed out, gh which the l we will use can ommend you use a nt, some as we varnish it to stop	Porcelain been a be use but at developm being use fine dinin plates, cu	might have tter material to this stage of ent, it was d mainly for g ware, such as ps and saucers.	Making easy. Y it is ma Wikipe (<u>https://</u> g/wiki/I be caref Wikipe sometin is not so	porcelain is not ou may see how de on the dia web site <u>(en.wikipedia.or</u> <u>Porcelain</u>) but ful about using dia as nes its accuracy o good.	Although they were no expert artisans, Antoine and Marie knew enough about wood to think of some of the problems that could arise.

	· · ·				
the mercury leaking through.					
Three days later, back in the Laboratory. Present: Monsieur Jacques Cabinet, Monsieur					
Antoine Lavoisier, Madame Marie	Lavoisier		N · ·		
Internet Lavoisier			something of an		
made and talk us through it			expert in her		
made, and tark us through it.			own right.		
Jacques Cabinet		Rubber	o will right		
You have room in the laboratory		tubing for a			
to make a good size container. I		gas delivery			
made this from the best		tube was not			
Rosewood I could find, sawn by		available at			
the best sawyers into planks. I		this time.			
used large planks 2 feet wide for		Often clay			
dovetailed to make very strong		ubling was			
ioints You will see that I have		was known			
only used a single piece of wood		through clay			
for the container bottom. I have		pipes that			
used the best wood glue I could		were used			
buy. The shelf is freely moving,		for smoking			
and made in a similar way. I have		tobacco. It			
cut a hole in the side, and on the		was easier			
top. This should allow the clay		to use than			
pipe to be fed in so that the gas		glass at this			
with mercury and placed upside		stage of			
down		chemisu y.			
Antoine Lavoiser		The			
A good job, I think Jacques. It		mercury			
will need a lot of mercury to fill		was stored			
it. The mercury is in these pots		in			
here. Will you help me to lift		earthenware			
them and fill the container,		(<u>http://www</u>			
please? Then we can start our		<u>.britannica.c</u>			
tomorrow		om/art/earth			
tomorrow.		pots as these			
		were			
		commonly			
		available.			
		They were			
		galxed on			
		the outside			
		to stop the			
		mercury			
The next day, back in the Laborator	ry Present: Monsieur Jacques Cabinet	Monsieur			
Antoine Lavoisier. Madame Marie	Lavoisier	monsicul			
Jacques Cabinet					
Oh dear! I thought this might					
happen. The mercury had leaked					
out.					
Marie Lavoisier			Marie tries her		
I cannot see how this would			best to explain.		
happen. You used the best wood,			Here her		
the best joints, and the best glue.			knowledge of		
Also, you varnished it very well.			wood 18 not		
Jacques?			is a well-known		
sucques:			member of the		
			community of		

artisans, and can be perform in any of these knowledgeable friends. acques Cabinet Intimatic an explain this. You usually have the functed on the form in any of these knowledgeable friends. acques is the created by acques is the created by any of these knowledgeable friends. Issued with a weak the functed on the function of the form in any of these knowledgeable friends. acques is the created by any of these knowledgeable friends. Issued with a weak the functed on the form in the form in the form in the form in the created by any for the mercury to leak out. I do not think that using wood can solve this problem. Thave a friend who may be able to help. See me here to morrow, please. See if you can solve the again. The next day, back in the Laboratory. Present: Monsieur Jacques Cabinet, Monsieur Antoine Lavoisier, Madame Marie Lavoisier, and joined by a stome mason Robert Graves Incques Cabinet Good morning Monsieur and Madame. Let me introduce my friend, Robert Graves. Incques Cabinet Good morning Monsieur and Madame. Let me introduce my friend, Robert Graves. Incques Cabinet Robert Graves. He is a stome mason Robert Graves It is an honour to meable to help. Please to meable to adde a and be to make a stome the adding stome in many different ways. It is an shord or thom ke a adding stome in adding stome in many different ways. It is an honour to meable to help. Stome mason is the created by the day with it meable to help. It is an honour to meable to help. It is an stated to make a stome to make a stome the stome stow					
Image: A standard of the set of the				artisans, and can	
and help from many of these knowledgeable friends. and help from many of these knowledgeable friends. Jacques Cubinet Jacques is the expert here. He is trusted by Antoine and Marie to find the or ma to the formation of the in theorems drive. This then opens the joints enough for the mercury to leads out. I do not this problem. I have a friend who may be able to help. See me have tomore, please. See if you can someone to take up the mercury. In addition, We can use it again. The next day, back in the Laboratory. Present: Monsieur Jacques Cabinet, Monsicur Antoine Lavoisier, Madame Marie Lavoisier, and joined by a stone mison Robert Graves Jacques Cabinet Stone masons. Good morning Monsieur and Madame. Let ure introduce my friend, Robert Graves. He is a stone mason. He may be able to help. Stone masons. Madame. Let we introduce my friend, Robert Graves. He is a stone mason. He may be able to help. Stone masons. Madame. Let reintroduce my friend, Robert Graves. He is a stone mason. He may be able to help. Stone masons. Marie and Antoine Lavoisier (logother) Stone masons. Please to meet you Robert. What ideu do you have? ways. Robert Graves ways. Stone masons. It is an honour to meet you, too. Sometimes, I am asked to make a coffin which is inpermeable, that is, water and creatures in the ground outside cannot get in. I use wholo piece of marble, which I then carve out from the inside, to make a kill to choose the best Nock of mercury without cracking. Shall I get to werk, now? I will work inside the Laboratory since the marble is heavy. Once I start work on ii, I do not withs to drop it. Where do you with it t				find good advice	
Image of these set of the set of th				and help from	
Jacques Cabinet knowledgeable friends. 1 thick I can explain this. You usually have the furnace on during the day. At night, the temperature drops and the room air becomes drive. 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. Have a friend who may be able to help. See me here tomorrow, please. See if you can someone to take up the mercury. In addition, We can use it again. 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 fricad, Robert Graves. He is a stone mason. He may be able to help. Stone masons Madame Cart Graves. He is a stone mason. He may be able to help. Stone masons Madame Let Graves. He is a stone mason. He may be able to help. Stone masons Madame Let Graves. He is a stone mason. He may be able to help. Stone masons We can the creatures in the ground outside cannot get in. I use whole prevers of the used to make a king to chook stone the single, that is, water and creatures in the ground outside cannot get in. I use whole prevers from the inside, to make a king to chook stone the single. Stone masons Ware it is unpermeable, that is, water and creatures in the ground outside cannot get in. I use whole prove of mathe, which I then carve out from the inside, to make a king to chook stone due sin? Artisans rarely worked alone, and the aprenti				many of these	
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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.		
<i>Marie Lavoisier</i> 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.		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 discovery.

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:

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.

Ask the young learners to read the play, and the context, for homework, to prepare for the next lesson.

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.

I suggest that they repeat the play with the roles changed. This will give them an insight into different perspectives.

After they have performed the play (one, two or three times), they discuss what they have learned.

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.

Further research

A next stage is to see how this works with different classes, and with different contexts for the plays and their histories.

Implications

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

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