



Module 12

SOCIO-SCIENTIFIC ISSUES AND ASSESSMENT



Worksheets



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Activity 1.2: What outcomes are we after when we teach through SSI?



Think-pair-share



30 mins

Think about the questions below. Then discuss with the person sitting next to you.

- What learning outcomes do we aim to achieve when teaching through SSIs?
- What possible challenges are involved when students learn through SSIs?
- What possible challenges related to assessment are there in relation to SSI lessons?





Activity 2.1: Introducing a dilemma: a Case Study



Reading



20 mins

Read the following introduction to a dilemma.

- When was the last time that you watched a pyrotechnic display? Fireworks are often part of our celebrations, be it the New Year celebrations or a national event. They are used to light up and colour the evening sky in some theme parks. They are also used by the military for training purposes. But have you ever thought about the possible environmental impact of the use of fireworks in celebrations and festivities?
- In Malta, fireworks make up one of the characteristics of the warm summer nights and days! All towns and villages have their Festa, usually during one of the weekends between June and September. There are around 85 such Festas every summer. Fireworks enthusiasts work throughout the year to create these fireworks during their free time in specially constructed sites. Many consider it to be a tradition and part of the Maltese culture. The artistic displays attract many local people and tourists and have been declared winners in international competitions.
- However, in recent years some concerns have emerged about the possible negative impact of pyrotechnics. These include health-related issues such as the high level of perchlorate in house dust and soil seeing that perchlorate is linked to thyroid disease; safety; noise.
- Read the articles provided for some information about the matter.

The first article is from a Maltese Newspaper (The Times of Malta) while the second is from a Chemistry journal called Chemistry World.

‘Tell the truth on fireworks’



22 June 2014|Caroline Muscat|



Chemical contamination from fireworks is found in homes and local produce, according to expert Alfred Vella who said evidence could no longer be hidden away just because it may be “an inconvenient truth for some”.

Laying out the science based on research conducted by the University of Malta, Prof. Vella said perchlorate, one of the more important chemicals used in fireworks and which has no regulatory limit, was found in homes from about 40 towns in Malta and Gozo.

Prof. Vella said residents are constantly in contact with this dust and transfer amounts of it to their stomach via hand to mouth, Prof. Vella said, adding that if you live in Malta, you are also ingesting perchlorate through your food.

The debate on such chemical contamination was sparked by amendments to regulations to make the practice “safer”.

But Prof. Vella, who had led the inquiry commissioned in September 2010 following a spate of tragic firework accidents, said he was not satisfied by the outcome even though the Home Affairs Ministry said the regulations were based on the inquiry’s report.

“We have clear evidence to show that certain crops, such as lettuce, when grown in local fields will likely contain the chemical,” he told The Sunday Times of Malta.

In comparison, researchers analysed imported (European) lettuce and found it did not contain perchlorate. The studies conducted over six years also discovered perchlorate in the shell of edible land snails.

“I suggest we stop denying the facts and face reality: it is absurd to expect that you can burn tons of chemical materials for months to celebrate over 85 feasts and expect the waste products from these combustion reactions to simply disappear. The white smoke of exploding petards is loaded with toxic chemicals,” Prof. Vella said.

He is not advocating a ban on fireworks yet said: “This is not alarmist talk but responsible reporting.”

This is not alarmist talk but responsible reporting

Labour MP Godfrey Farrugia last week defended the regulations, saying licensed pyrotechnicians have been gradually switching from chlorates to perchlorates to improve health and safety standards.

Dr Farrugia, who was the pyrotechnics association’s secretary until his appointment as health minister, said health risks linking perchlorate concentrations to thyroid disorders are debatable. He pointed to pollutants from traffic and the power station, saying: “We must adopt a more positive, proactive approach to pyrotechnics.”

Prof. Vella contested the argument: “Perchlorate has absolutely nothing to do with traffic emissions. Its presence in our environment is due solely to the tons of material imported annually for one use only: namely, to produce the bombi (petards) in honour of saints,” Prof. Vella said.

He said Malta probably has “a world record of perchlorate contamination” as it is found in dust fall throughout the year – increasing by factors of 100 to 500 between June to September.

Medical science states that perchlorate is a chemical known to affect the function of the thyroid gland, especially in infants, pregnant women, and foetuses.

“Is the chemical capable of inducing cancer when humans are exposed to low concentrations over an indefinite period, as happens locally? Science doesn’t know.

“It does know that perchlorate causes cancer in laboratory rats. Should we allow people, especially children, to be exposed to this potential danger? Do we, in Malta, have a problem with thyroid health, especially in females?”

He said findings on airborne dusts were published in a peer-reviewed international journal and show unequivocal evidence that air quality is permanently reduced during the summer period with the presence of toxic metals in the respirable fine dusts (PM10) – these metals (including barium, copper, and antimony) are not related to traffic emissions or the power station.

He says the precautionary principle mandates “we mitigate the risk” and the control mechanism available is to reduce the quantity of fireworks.

Happily ever after

At first glance, a Disney theme park might not appear to have much in common with a military training ground. But it turns out that both are amongst the heaviest users of pyrotechnics in the US, and their neighbours don't like the resulting impact on their environment.

For Disney, the problem lay in the plumes of smoke that would drift out of the park and across surrounding suburbs following their frequent fireworks displays. Smoke isn't just a problem with civilian fireworks displays – it is also a problem for military pyrotechnics, particularly for light-emitting flares, where the smoke can obscure the light.

In the late 1990s, that was just the issue that a team of chemists at Los Alamos National Laboratory (LANL) in New Mexico were trying to address using energetic compounds rich in nitrogen. 'During that time, Disney was interested in reducing the smoke in their outdoor pyrotechnic displays, and so they approached the group and asked what might be some possible solutions to their problems,' recalls David Chavez, a member of the team who still works at LANL.

Disney's fireworks are now based on derivatives of LANL's original high-nitrogen compounds. A small business called DMD systems was set up

by some of Chavez's former LANL colleagues to develop Disney's formulations. The commercial applications of the LANL research haven't been limited to theme park displays, however. Since the

early Disney research, the company has gone on to pioneer the use of high-nitrogen compounds for indoor pyrotechnics, used for example in concerts and theatres.



Fireworks display behind Disneyland's Cinderella castle

ENL057P380

18 | Chemistry World | January 2012 | www.chemistryworld.org



Activity 2.2: Initial opinion forming



Individual



10 mins

On an individual basis, think about the dilemma presented in these articles, write down notes and form an opinion.

- **Should the use of fireworks be controlled or even banned?**





Activity 2.3: Take a position on a controversy line



Discussion



20 mins

Form a line across the room, representing the level of agreement with the statement: **“Fireworks should be banned”**.

- Position yourself along the line depending on the extent of agreement.
- Explain and discuss your position with your neighbours on the line and ask questions.





Activity 2.4: Asking questions related to the controversy

Individual work



Group work



30 mins

- On an individual basis think of questions that you would like to ask to help you understand better the dilemma.
 - What is the controversy?
 - Who are the stakeholders? What are their interests?
 - What mathematics/science content knowledge is relevant?
 - Which questions might the issue raise that you can investigate?

- Share your questions in a small group. Which of these questions would you like to work on and investigate?





Activity 2.5: Planning an inquiry related to the SSI



Work in groups



30 mins

- Plan an inquiry related to the controversy to answer your chosen question/s and to obtain information that is not available regarding the issue.
- During the coming two weeks you will work on the inquiry and produce a short video in which you present your findings and your position as a group with respect to the dilemma.





Alternative Activity 2.5: Analysing data related to the SSI



Work in groups



30 mins

- Consider the information and data given below related to the controversy.
- Find different ways of analysing the data and use the information when presenting your arguments. During the coming two weeks you will work on the analysis and produce a short video in which you present your findings and your position as a group with respect to the dilemma.

Impact of fireworks on air quality

Adapted from Camilleri, R. & Vella, A. J. (2010). Effect of fireworks on ambient air quality in Malta. Atmospheric Environment, 44(35), 4521–4527.

Religious *festas* are a characteristic of summer in the densely populated Maltese islands (population around 500,000; area 316 km²), when 86 *festas* are celebrated between June and October, each involving the burning of fireworks in ground and aerial displays, usually over a period of three days or longer per *festa*. In 2007, for example, 200 tonnes of chemicals related to the manufacture of pyrotechnic material were imported (NSO, 2007). Smoke from fireworks is harmful if inhaled. Airborne particulate matter (PM) is a complex mixture of solids and aerosols. Particles vary widely in size, shape, and chemical composition. When monitoring air quality, particles are defined by their diameter. Those with a diameter of 10 micrometres or less (PM₁₀) are inhalable into the lungs and can cause adverse health effects.

A study carried out by Camilleri and Vella (2010) attempted to investigate whether the burning of fireworks in Malta throughout the long *festa* season was exerting a significant impact on the local air quality. The objective of the study was to establish whether the concentration and composition of PM₁₀ in ambient air in Malta is affected measurably by fireworks emissions.

They assessed the effect of fireworks on air quality by measuring PM₁₀ and its content of the metals aluminium (Al), barium (Ba), copper (Cu) and strontium (Sr). These materials are used in pyrotechnic material. Copper, barium and strontium produce colour. Antimony (Sb) is present in the compound used to light the firework. It is a possible carcinogen.

PM₁₀ was collected mainly from two sites, one in Malta (Zejtun: an urban background site) and the other in Gozo (Ta' Gordan: a rural site) from July to October 2005. For both Malta and Gozo, PM₁₀ and metal concentration levels were measured as weekly means. The prevailing winds blow from the Northwest. The Ta' Gordan site, in the northwestern part of the island, was upwind while Zejtun is a southeastern town and downwind from the mainland areas. One 24-hour sample was collected on 28th April 2006 from a locality (Cospicua) close to the urban site involved in the study. The number of *festas* celebrated over the period July to October 2005 were July: 32; August: 27; September: 10 and October: 1.



Table 1 Mean mass concentration and chemical composition of PM₁₀ for samples taken from Zejtun Malta

Sampling start date		20/7	27/7	3/8	8/8	17/8	27/8	30/8	6/9	13/9	27/9	7/10	15/10	20/10
Mean Weekly PM ₁₀ (µg m ⁻³)		42.9	49.6	58.0	40.1	37.1	28.5	41.6	40.3	39.3	25.1	27.1	33.3	42.7
Mean weekly concentration (ng m ⁻³)	Cu	10.9	11.6	9.0	3.2	9.2	5.6	6.5	1.7	11.6	4.7	5.3	4.7	2.4
	Sr	8.3	12.8	14.7	5.8	14.2	4.7	4.7	6.6	16.5	3.2	3.7	3.0	6.7
	Ba	18.3	33.2	18.4	28.4	46.6	10.2	4.9	4.5	17.2	4.6	5.5	3.8	3.9
	Al	348.0	413.7	357.5	75.5	298.0	106.1	105.6	79.5	389.8	56.8	101.2	41.8	190.9
	Sb	20.9	19.3	3.1	0.9	2.7	2.4	1.7	0.9	2.7	1.3	1.0	1.1	0.3
Precipitation		-	-	-	-	-	>2mm	-	-	-	>2mm	-	-	-

Table 2 Mean mass concentration and chemical composition of PM₁₀ for samples taken from Ta' Gordan, Gozo

Sampling start date		28/7	1/8	9/8	25/8	31/8	13/9	20/9	27/9	7/10	14/10
Mean Weekly PM ₁₀ (µg m ⁻³)		35.2	39.6	21.2	14.4	24.2	17.6	10.2	11.5	13.3	17.8
Mean weekly concentration (ng m ⁻³)	Cu	4.2	2.8	1.7	1.1	2.9	1.2	1.2	1.2	0.8	1.4
	Sr	4.7	6.3	2.7	0.9	2.2	2.4	1.3	1.5	1.5	1.8
	Ba	5.0	5.4	1.7	4.3	3.5	6.5	0.9	1.0	1.3	1.2
	Al	253.2	511.4	89.7	31.4	89.9	119.5	12.1	33.8	38.2	53.8
	Sb	0.3	0.5	0.2	0.7	1.9	0.4	0.3	0.2	0.1	0.4
Precipitation		-	-	-	>2mm	-	-	>2mm	>2mm	-	-

Table 3 Mean mass concentration and chemical composition of PM₁₀ for samples taken from Cospicua, Malta

Sampling date		28/4/2006
Mean Daily PM ₁₀ (µg m ⁻³)		42.0
Mean daily concentration (ng m ⁻³)	Cu	4.4
	Sr	4.8
	Ba	2.1
	Al	99.8
	Sb	0.8
Precipitation		-

References

Camilleri, R. & Vella, A. J. (2010). Effect of fireworks on ambient air quality in Malta. *Atmospheric Environment*, 44(35), 4521–4527.

NSO (National Statistics Office, Malta), 2007. Report for 2007, Malta.



Activity 2.6: Presenting results of the inquiry



Whole group



30+10 mins



- Presentation of short videos of the inquiry.
- Discuss the inquiry, methods used, findings and your position with respect to the dilemma.



Activity 2.7: Arriving at a decision



Work in groups



30 mins

- In your group discuss and arrive at a decision with respect to the dilemma after considering different arguments, different interests, values, scientific ideas, and scientific uncertainties.
- What action may be taken based on this decision (e.g., writing a letter to a fictitious newspaper or an authority and so on)?
- Plan the action.





Activity 3.2: Reflection and Evaluation using self- and peer-assessment



Individual work



30 + 10 mins



Work in groups

- Use the rubric to evaluate competences demonstrated in the videos related to the SSI dilemma. You will evaluate your group's video and those of other groups.
- What are the benefits of self- and peer-assessment on further development of skills and competences related to dealing with SSI?



Assessment Rubric for SSI

Based on Simon, Erduran and Osborne (2006); Schen (2013); Christenson and Rudgren (2015)

Aspect	0 – Unsatisfactory/poor	1 - Beginning	2 – Progressing but needs further development	3 - Outstanding
Claim/decision	No claim made or is irrelevant to data/scenario.	Claim made but it is too broad.	Claim made is weakly supported by data/scenario.	Claim is clearly supported by data/scenario.
Evidence/data Statements used as evidence to support the claim	No evidence given or evidence is irrelevant to claim.	Evidence given is too unspecific or raw data given as evidence, no trends identified.	Some non-specific evidence or raw data given with some trends identified.	Specific evidence given with trends and examples identified; shows interpretation.
Warrants/Reasoning Statements that explain the relationship of the data to the claim	No reasoning made or reasoning is irrelevant to data/scenario.	Restatement of the data or vague principle given.	Principle stated is not vague but is not specifically connected to evidence or claim.	Principle stated with clear, specific relationship to evidence and/or claim.
Use of Counterclaim/alternatives to the claim/consideration of other standpoints.	No counterclaim or consideration of other positions; or counterclaim is irrelevant to data/scenario.	Counterclaim is too broad.	Counterclaim is weakly supported by data/scenario.	Counterclaim is clearly supported by data/scenario.
Rebuttals	No rebuttal to the alternative position.	Weak opposition to the alternative position.	Rebuttal weakly supported by data/scenario.	Rebuttal clearly supported by data/scenario and directly opposite to the counterclaim.
Use of qualifiers	No use of qualifiers made	Condition when a claim would no longer hold and/or when a counterclaim would hold is given but no explanation is provided.	Condition when a claim would no longer hold and/or when a counterclaim would hold is given but explanation is limited.	Clear explanation of the condition when a claim would no longer hold and/or when a counterclaim would hold.
Socio-scientific reasoning and awareness	Arguments and reasoning simplistic and show limited or no awareness of the complexity of the issue.	Arguments and reasoning attempt to present more than one perspective but do not employ scepticism or ask	Arguments and reasoning show most but not all of the following: awareness of multifaceted nature of the issue, ability to analyse the	Arguments and reasoning show awareness of multifaceted nature of the issue, ability to analyse the issue from multiple

		questions that go beyond the information available.	issue from multiple perspectives; recognises need for additional information and employs scepticism in information provided by parties with possible vested interests.	perspectives; recognises need for additional information and employs scepticism in information provided by parties with possible vested interests.
Content in favour of the claim	No content knowledge (or data) provided as supporting ground.	Incorrect knowledge (e.g. scientific) provided.	Knowledge included is not directly related to the issue.	Correct and relevant content knowledge included
Content in the rebuttal	No content knowledge (or data) provided as supporting ground.	Incorrect knowledge (e.g. scientific) provided.	Knowledge included is not directly related to the issue.	Correct and relevant content knowledge included.
Values and moral reasoning	No values or moral reasoning evident.	Value statement but not supported by reasoning.	Values and moral reasoning included in the argument, but this is limited to effect on oneself and does not consider the broader and long-term consequences.	Values and moral reasoning included in the argument that consider the broader and long-term consequences and go beyond effect on oneself.



Activity 3.3: How can a rubric be used for formative assessment as part of SSI lessons?



Whole group discussion



Homework in groups



20 mins + homework

Discuss:

How may a rubric be used for formative assessment as part of SSI lessons to provide feedback to students?

For Homework

Work as a group to prepare a modified rubric with wording appropriate for use with science students of a particular age. Choose the age and state this on the modified rubric.

