Clean Water: A limited non-renewable resource
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Title: Clean Water: A limited non-renewable resource

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Water Resource for the Australian Science Curriculum

Introduction

This resource is intended for science teachers who wish to use the topic of water to incorporate the *Science as a Human Endeavour* strand into Year 7 *Chemical Sciences* or *Earth and Space Sciences* (Australian Curriculum, Assessment and Reporting Authority (ACARA), 2020). The resource enables science teachers to develop an understanding of how to use socioscientific issues to develop their students’ critical thinking, decision-making and argumentation skills.

Introduction to

What are Socioscientific Issues?

Socioscientific issues (SSI) are topics with a scientific basis which are important to human society. They are often controversial, with a range of views in society as they may involve ethical, social, economic, religious or political considerations. The science underpinning these issues is usually multidisciplinary, involving more than one area of science and the science itself may be contested. These issues are very often debated in popular media. Examples include: climate change, population growth, nuclear energy and genetically modified foods.

Why are they important to teach?

Including SSI in your science teaching increases the relevance of science to students’ everyday lives and can improve students’ engagement and attitudes to science. There can also be an improvement in students’ scientific literacy and their academic achievement.
**How can I include issues in my teaching?**

Because SSI are controversial, students may hold strong and firm beliefs about an issue. Effective teaching strategies thus aim to provide accurate and up-to-date science content and give students the information which enable them to make and justify their decisions about an issue. It is also an opportunity to raise students’ awareness of an issue which may impact their lives in some way.

Teaching strategies used to teach SSI include:

- **Co-operative group work.** This involves students working together as a team. Benefits of this include development of social skills such as leadership and communication, as well as more effective learning as students listen to, and learn from each other.
- **Role plays.** This is where students act out different parts of people who may be affected by an issue. This allows students to consider different point of views of an issue (perspective-taking).
- **Debate.** Students form teams representing two sides of an issue: for and against. Students can be randomly placed on a team or choose which side they would like to represent. They then argue in front of members of the class, who judge and provide feedback on the value of their arguments.
- **Independent research.** This can be in the form of a structured or open assignment where students research and report the pros and cons of an issue before arriving at a position (also called a position paper).
- **Consensus meetings.** This can be performed in small groups or whole of class and involves students discussing and negotiating the issue until they all come to an agreement.
- **Hypotheticals.** Students are provided a hypothetical situation and need to analyse the situation making decisions based on provided information.
Introduction to Decision-making and Argumentation

What is Decision-making?
Decision-making is a process of asking relevant questions (inquiry), weighing up risks and benefits (pros and cons, advantages and disadvantages), considering the consequences (long and short term), querying the source and credibility of evidence, taking into account the multiple perspectives of stakeholders, and recognising the complexity, tentativeness and subjectivity of decision-making.

In science, we can weigh up the pros and cons using the bioethical principles of autonomy (personal free will), beneficence (for the benefit of others), non-maleficence (do no harm), and fairness (equity).

Students may need explicit scaffolding to develop their decision-making skills. Suitable questions to support decision-making are:

1. What further information would help in making your decision?
2. What are the possible advantages of your decision?
3. What are the possible disadvantages of your decision?
4. If someone disagrees with you, how would you convince them that your decision is the best?

What is Argumentation?
It is important to be able to defend or justify decisions. This process is called argumentation. An argument is a claim (decision) with supporting evidence. Engaging in argumentation can increases students’ understanding of science as they use their scientific knowledge in authentic ways. The ability is construct an argument
is explicit in the Australian science curriculum under the Science Inquiry Skills strand for Years 7-10 (ACARA, 2020).

- Use scientific knowledge and findings from investigations to evaluate claims based on evidence. Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data. (ACSIS117)
- Critically analyse the validity of information in primary and secondary sources and evaluate the approaches used to solve problems. (ACSIS172)
- Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations. (ACSIS174)

What are the parts of an argument?
A well-constructed argument consists of a claim with justification (data, qualifiers, backings and rebuttals).

- **Claim** is an assertion about what exists or is believed.
- **Data** are statements that are used as evidence to support the assertion.
- **Qualifiers** are specified conditions under which the claim holds.
- **Backings** are assumptions or generalisations that support the data.
- **Rebuttals** are statements which contradict the data or backings of an argument.
- **Counter claims** are opposing assertions.

Example of an argument
West Coast Eagles are a better football team than the Fremantle Dockers. They have won more football matches at home and away because their players have superior skills.

Claim (West Coast Eagles are a better football team)
Data (They have won more football matches)
Backing (They have superior skills)
What could be a qualifier? (Only in some years)
What could be a rebuttal? (Even though Dockers finished higher on the league table, Eagles beat them more often)
What could be a counter claim? (Dockers are a better football team)
Critical Thinking

Being able to make decisions and contribute to public debate about controversial topics is an important outcome of science education. Teaching through SSI provides opportunities for students to develop and use their critical thinking skills to analyse and synthesise scientific information to make and justify decisions about how to act, that is, create arguments.

Critical thinking is the ability to think rationally and reflectively when deciding what to believe or do (Ennis, 1985).

An important aspect of critical thinking is the ability to construct and evaluate arguments. Facione (1990) developed an extended definition of critical thinking through a Delphi study and found that critical thinking comprises both cognitive skills and dispositions. Specific cognitive skills and sub-skills have been identified including analysis, evaluation, interpretation, explanation, and argumentation (Abrami et al., 2015). Critical thinking dispositions identified include open-mindedness, flexibility, intellectual curiosity, and suspending judgement.

Abrami et al., (2015) found that the most effective pedagogical approaches are those that use a combination of three pedagogical strategies: authentic (personally relevant), real-world problems such as role plays; dialogue comprising teacher-led discussion which could be whole class or small group, face to face or online, adversarial or co-operative; and coaching, which was defined as explicit modelling, questioning and probing by the teacher and peers.

Critical and creative thinking is a general capability of the Australian curriculum. The critical and creative thinking learning continuum states that ‘by the end of year 10, students: use logical and abstract thinking to analyse and synthesise complex information to inform a course of action’ and ‘assess risks and explain contingencies, taking account of a range of perspectives, when seeking solutions’ (ACARA, 2020).

For further information about the teaching of critical thinking, refer to the excellent discussion paper, How to teach critical thinking, by Daniel Willingham (2019) commissioned by the NSW Department of Education.
Role of the Teacher

The actions of the teacher are crucial in developing students’ argumentation skills about SSI. Previous classroom research has shown that the following strategies are effective. The teachers who were most effective reiterated steps 4 and 6-8.

1. Encourage talking and listening
2. Help students know meaning of argument
3. Encourage positioning – taking a side
4. Encourage justifying with evidence
5. Help students construct arguments
6. Model evaluating arguments and evidence
7. Encourage rebuttals
8. Encourage reflecting on argument process (mind change)

(Simon, Erduran & Osborne, 2006)

Questions that encourage argument development are:

1. Why do you think that?
2. What is your reason for that?
3. Can you think of another argument for your view?
4. How do you know?
5. What is your evidence?
6. Is there another argument for what you believe?

Osborne, Erduran, & Simon (2004).

Classroom Environment

Our previous research and that of others have shown that simply using controversial issues in science doesn’t necessarily improve argumentation skills. The following classroom factors promote critical thinking:

- Ensure there is a safe classroom environment where students may express their views and beliefs without ridicule
- Ensure that students understand that during discussion they need to listen to their peers and be willing to justify their views and ask questions
- Understand that the purpose of class discussion is to reach consensus rather than the right answer – termed collective sense-making
- Value a culture of thinking and willingness to change views
- Encourage student to be skeptical and questioning of claims

For further reading about how to reason about SSI, refer to the paper, *Controversial issues in the science classroom* by Owens, Sadler and Zeidler, (2017/2018).
Water as a Socioscientific Issue

Providing sufficient clean water is a global problem and clean water and sanitation is listed at number 6 of the UNESCO sustainable development goals (UNESCO, 2019). Although one can teach the topic of water as a renewable resource (e.g., through the water cycle) clean drinking water is a non-renewable resource with particular significance in an Australian context.

Australia has long experienced periods of drought, and water availability is an acute problem in many areas. As Australia’s population has increased, drought has had devastating impacts on agriculture and wildlife. In the Southern parts of Australia, climate change has contributed to reduced annual rainfall (and increased average and summer temperatures) in previously arable land. Many rural communities now truck water in to supplement limited rainwater catchments. In December 2018, the Murray-Darling Basin in the south-east of the continent, experienced extraordinary fish deaths over a 40km section with over a million fish dying in a short period of time. An inquiry concluded that lack of water due to extreme drought and a rapid change in temperature causing algal bloom led to the fish deaths.

This resource uses the Year 7 content area of water use as the SSI context. The topic of water forms part of the Year 7 science curriculum (ACARA, 2020). The Earth and Space Sciences understanding outcome, states ‘Some of Earth’s resources are renewable, but others are non-renewable’ (ACCSU116) and ‘Water is an important resource that cycles through the environment’ (ACSSU222).

Further, the Science as a Human Endeavour strand has the following elaborations as examples of contexts to be taught in Year 7 (ACSHE223 and ACSHE120): ‘considering how water use and management relies on knowledge from different areas of science and relies on application of technology and, ‘considering issues relating to the use and management of water within a community’.

What follows are two 60 minute lesson plans with accompanying Powerpoint and SSI scenarios which can be used to introduce argumentation about SSI in a water context. The lesson format, Powerpoint and SSI scenarios have been trialled by science teachers and their Year 7 students.
Sample lesson plans – Water, Decision-making, Argumentation and Critical thinking

**LESSON 1 60 minutes**

**Introduction (5 minutes)**
**Aim of lesson** – to learn how to construct a sound argument to justify decisions about water use

**Question (10 minutes)**
What are some aspects of water that the public is worried about? – ask why it is an issue

- Water quality – although water can be considered a renewable resource, clean drinking water is a non-renewable resource
- Water availability – Murray-Darling Basin and irrigation, trucking of water in regional communities
- Recycled water from sewerage
- Water cost – who pays for water availability and water treatment, desalination plants
- Climate change and changed rainfall patterns, drought and flooding

**What is an argument? (15 minutes)**

- When making a decision about issues in science there is often disagreement (eg climate change). You need to convince others that you are right. How do you do that? (Good argument using reasoning and scientific evidence).

- Ningaloo conservation argument PPt. Shows an example of a good and a poor argument about conservation at Ningaloo reef and structure of an argument

- After PPt – ask the following, What are the features or parts of a good argument? (can put on board to refer to later).

**Claim** – decision
**Data** – scientific evidence, logical reasons
**Warrant** – linking data to claim (e.g., this is true because)
**Backing** – underlying assumptions or rules
**Qualifier** – conditions under which claim is true
**Rebuttal** – why others’ arguments are wrong

**SSI water scenario (30 minutes)**

Damn it- what is the right thing to do?
1. Handout writing frame, read aloud to students, and explain unfamiliar words.

2. Students by themselves make a decision (this is the claim).

3. Students by themselves answer first three questions (this encourages use of evidence and backings).

Q1 important as shows importance of asking questions and needing more information before making a decision.

Q2 ask for data, evidence, backings

Q3 considering disadvantages requires consideration of qualifiers (exceptions).

4. Tally the claims on board (yes, I don’t know, no)

5. As a class discuss Q1 (you may want to answer some of their questions).
   As a class discuss advantages and disadvantages of the dam construction.
   In this part encourage students to give their evidence and backings and use as much scientific evidence as possible, play devil’s advocate. Praise the use of scientific language and evidence, listen to alternative views, and generate rebuttals.

6. Q4 is optional but encourages students to consider alternative claims and evidence and develop rebuttals.

Redo tally about claims—emphasise it is OK to change your mind, to ask questions. Emphasise that hearing the advantages and disadvantages of different claims helps them to consider if their decision is justified.

Collect writing frames to complete the following lesson and review responses from students who didn’t speak.

**LESSON 2 60 minutes**

1. **Review parts of an argument (15 minutes)**
   Ask students what an argument is and what the parts are. Might be helpful to write first letters on board
   C
   D
   W
   B
   Q
   R
2 Any questions or thoughts on dam water scenario.

3 Repeat the construction of an argument using a writing frame with either provided SSI or self-developed scenario (30 minutes)

4 During class discussion reinforce listening to others, evaluating arguments and generating rebuttals. Ask about mind change.

5 Collect writing frames.

6 Debrief on process – was it useful to listen to views of others? (hopefully yes) Why is this important? (appreciate complexity of issue, different stakeholders, alternative options)
Ningaloo Conservation PowerPoint
Modified from a version produced by Chris Hawkins, Penrhos College
What is an argument?

- When making a decision about a scientific issue, there is often disagreement e.g. some people don’t agree that climate change is real.
- You need to CONVINCE others that you are right.
- How do you do that?

By presenting a good argument that uses reasoning and evidence.

Ningaloo marine argument

A marine biologist and a fisherman were overheard arguing about the government’s decision to increase sanctuary zoning along the Ningaloo reef from 10% to 34%.

"I think it was a good decision by the government to increase the amount of sanctuary zones."

"No. I think it was a poor decision."

"Coral reefs around the world are in trouble. An estimated 30% are already severely damaged as a result of human influences such as development and overfishing, and global warming threatens to bleach thousands of kilometres of coral. Experts say close to 60% of the world’s coral reefs could be lost by 2030. I’m glad the government has done something to ensure the protection of the reef."

"Neh, it’s a bad decision. I want to be able to fish where I want!"
"There are still huge areas open to fishing. Similar projects in other areas have proven that sanctuary zones provide fish with a safe haven to breed and fish species tend to increase in numbers so it would actually be a good thing for fishermen too."

"No, I can't fish in as many spots and I won't catch as many fish!"

"Two thirds of the reef is still open to recreational fishing but we need one third protected for the benefit of the whole reef. If you want me I will show you some of the results of our past studies where fish numbers have rapidly increased once sanctuary zones have been cut in place..."

"Shut up I hate you." (Blocking his ears) "I'm not listening. I'm not listening."

Who had the better argument?
- The marine biologist or fisherman?
- Why?

Arguments consist of:

CLAIMS: Main idea of the argument.

DATA: Statements or reasons used as evidence to support the claim.

QUALIFIERS: Specified conditions under which the claim holds true.

BACKINGS: Underlying assumptions which support and back up the data.

REBUTTALS: Statements which contradict either the data, backing or qualifier of an argument.
Water SSI Writing Frames for use with Year 7 Students

Damn it: What is the right thing to do?

Mrs Jones’ neighbour is so boring

Hampton Waters: Would you rather swim in it or drink it?
Damn it: What is the right thing to do?

The Council of Boronga have proposed the building of a new dam on the Smithton River. The Council has concluded that the dam is needed for three reasons. First the dam will provide flood relief for the main town of Boronga. Recently, Boronga has experienced two large floods causing significant damage and loss of livestock. Second, with the dam, a new lake will provide drinking water for Boronga. The Department of Water has predicted in the future, that with current water use and falling rainfall, there will be reduced water available from underground aquifers. Three, the new lake will also provide recreational activities such as boating and fishing. New homes and resorts will be constructed giving the area a much needed economic boost and tourism income.

However, the area that would be flooded for the dam is a sensitive ecological area that serves as a breeding ground for fish, birds and other wildlife. Wildlife officials are concerned the dam will eliminate the habitat of two endangered native birds. Furthermore, the area has a rich farming history and the local farmers will lose their farming land due to flooding caused by the dam.

If you were a city counsellor would you vote for the dam?
Yes No I don’t know

Write an argument to convince someone that your answer is correct.
1. What further information would help in making your decision?

2. What are the possible advantages of your decision?

3. What are the possible disadvantages of your decision?

4. If someone disagrees with you, how would you convince them that your answer is the best?
Mrs Jones’ neighbour is so boring

Mrs Jones has a native garden which she can water on her rostered two days a week. Her neighbour has a lovely tropical garden, including flowers and fruit trees, which he can water three days a week because he has an underground **bore** (see diagram). She thinks her native garden is quite plain and would like to have a beautiful garden and grow fruit like her neighbour, so is considering installing a bore. Her daughter has told Mrs Jones that removing water from the groundwater by using a bore, affects the local lake ecosystem which has been drying out due to reduced rainfall.

**Glossary**: A bore is a deep hole dug into the ground, from which users can access groundwater. A homeowner with a bore is allowed to water their garden three days a week in Western Australia.

If you were Mrs Jones, would you install a bore system?

Yes ☐  No ☐  I don’t know ☐

Write an argument to convince someone that your answer is correct.
1. What further information would help in making your decision?

2. What are the possible advantages of your decision?

3. What are the possible disadvantages of your decision?

4. If someone disagrees with you, how would you convince them that your answer is the best?
Hampton Waters: Would you rather swim in it or drink it?

Due to decreasing rainfall in the local area, the Council of Hampton is considering using the local dam called Hampton Waters, for drinking water. They believe it is better for the local ecosystem to use the dam water instead of water from underground reservoirs. To reduce the cost of water treatment, they will need to ban locals using Hampton Waters for recreation. This means no canoeing, no fishing and no swimming. Many locals are upset as Hampton Waters is the only large body of water in which to swim for 150km and is a popular community location. The Hampton Council has asked locals to vote on this decision.

If you were a Hampton local would you vote to swim in Hampton Waters?

Yes ☐ No ☐ I don’t know ☐

Write an argument to convince someone that your answer is correct.
1. What further information would help in making your decision?

2. What are the possible advantages of your decision?

3. What are the possible disadvantages of your decision?

4. If someone disagrees with you, how would you convince them that your answer is the best?
Water Curriculum Resources

**Science by Doing** http://www.sciencebydoing.edu.au
Register as a teacher to access these inquiry-based curriculum materials

*Year 7 Chemical Sciences - Enough water fit for drinking*

The whole resource on the topic of water is a term’s work and *Part 6 How can science help us make evidence-based decisions?* uses the example of recycled water as an SSI. *Part 7 How might you defend your position?* has a teacher rubric to evaluate students’ decision-making process.

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**Earth Science Western Australia** http://www.earthsciencewa.com.au

This site has an extensive range of resources on earth science for primary and secondary science. Go to the WASP resources *Year 7 Oil and Water* which examines the chemistry of water and the WASP Year 7 STEM package resource, *Recycling Water* which provides scaffolded, guided and open inquiry to understand water use and develop recommendations to reduce or recycle water waste.

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**Waterwise Schools Program** http://www.watercoorporation.com.au

This site contains resources for primary and secondary teachers on dams, groundwater and recycling of water. They provide guest speakers on water supply, desalination, aquifers, Perth’s water future, water pollution, water conservation and water on Aboriginal culture.

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**Water Education Cases** http://www.waterliteracies.org.au

This site provides case studies of three year 5 classes to demonstrate how the topic of fresh water can be a transdisciplinary topic across multiple curriculum areas. Worth a browse.

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**Australian Water Association** http://www.awa.asn.au

This site has a section for Teacher Resources with a Water Educators Toolkit. Produced in 2016, it links to the Australian curriculum and includes student centred activities on the water cycle, water catchments, water sources, water treatment and water management.
References


