International Journal of Engineering, Construction and Computing
Volume 1 Issue 1, 2019
ISSN: 2209-332X(Print)

Water Education: A Case Study in New South Wales Australia

Jenis F Islam[1,]*, Sumya Rahman[2], Imran Rahman [3]
[1]School of Computing, Engineering and Mathematics, Western Sydney University, Australia
[2] EnviroWater Sydney, Sydney, Australia
[3] University of Technology Sydney, Australia
*Corresponding author's email: jenisislam04@gmail.com

Peer review history
Manuscript submitted: 16 July 2019
Review process completed: 19 August 2019
Manuscript finally accepted: 20 August 2019
Handling Editor: Professor Ataur Rahman

Abstract: *Water is vital source of life. In developed countries, we are extremely fortunate to be able to access water at our fingertips, with little cost. Consequently, our water use is so much that per capita, per day water demand in Sydney is about 303 litres. In contrast, about 1 billion of the world's population does not have access to as little as 5 litres of safe drinking water per day. Access to safe drinking water is regarded as a basic human right, but to our surprise, approximately one-fifth of the world's population does not have access to safe drinking water. Water is also an integral part of the eco-system. Educating our school students about water is important so that this precious resource is preserved and enhanced for all the human beings. This paper presents an overview of water education in New South Wales. It has been found that New South Wales' school children receive basic education on water such as learning about the hydrologic cycle and water recycling but limited mathematical aspects of water management are taught. Due to climate change, increasing water demand and increasing pollution will make water accessibility a challenging issue in the near future. Water education will assist to achieve sustainable water development practices in Australia.*

***Keywords**: Water, School education, Water education, Teaching and learning.*

1. Introduction

Water is one of the most important resources for our survival on this planet. Water is directly consumed by human beings and is the cornerstone of sustainable development. Water is further used in recreational activities and most of our food production directly depends on water. To manage water resources, we need to educate the society at different levels. We need water experts who can treat, transport and reserve water for us. At the same time, an ordinary person needs to know how to save the water. In many locations, a person has to travel long distance to fetch drinking water. Many people in the world do not have access to clean drinking water, which hinders their growth and undermines their quality of life.

Water is linked with many different disciplines of knowledge (Rahman et al., 2018). Water education starts from early childhood at the household level, e.g. distinguishing clean water from contaminated water, washing hands with clean water before taking food and turning off the tap when it is not needed. School children learn water science in many different subjects. In the universities, there are subjects that teach water science or engineering at a greater depth in order to produce water experts. These water experts manage water resources in a country and their typical jobs include provision of clean drinking water, flood management, irrigation project management, wastewater treatment, clean-up of rivers and bays and water recycling and conservation. A water expert needs diverse knowledge often encompassing multiple disciplines such as mathematics, physics, chemistry, biology, economics and sociology. They often study specialist subjects such as fluid mechanics, hydraulics, hydrology, water treatment, fluid dynamics and water resources management. Due to the intrinsic relationship of water with the environment, water has been made as a subject of study in many disciplines of knowledge (Grimmond, 2010).

This paper presents an overview of water education in Australia. At the beginning, it presents general aspects of water. This is followed by an overview of grand water challenges. The importance of water education is then highlighted, which is followed by an overview of water education in NSW schools.

2. Water: Origin, Composition Myths and Importance

Water has been an integral part of every facet of society. It has presented itself from religious texts to agriculture and urban planning. The various stories of water indicate the long-standing curiosity and affinity humans have had with water.

As noted by Biswas (1970), the history of mankind can be written in terms of human interactions and interrelations with water.

Throughout the ages water has permeated into the stories, legends and myths of cultures around the world; Scottish mythology describes a translucent water creature that is mistaken for ghosts. Scandinavian folklore claims the existence of a horse that would lurk near rivers during foggy weather. If anyone tried to ride the horse, the horse would jump into a river and drown their rider who would be trapped and unable to separate itself from the horse. Aboriginal stories talk about an evil spirit, the Bunyip who lived in water areas, eating humans and spreading disease through water. Dragon Kings from Chinese mythology ruled over the four seas of China. From the Kraken, Jengy, Grindylows and Leviathan - creatures of the water are myriad. Just as many stories exist about creatures of water, there are legends where water plays a significant part in the story, such as the River Styx which granted invincibility to Achillies' entire body, excluding his heels. This became his eventual downfall when an arrow was shot into his heels, or the story of Manu from Hindu mythology, who survives a flood when he finds a fish in the form of a God in the river.

Stories of the past show the fascination humans have always had with water. As science progressed, the knowledge and importance of water progressed also. It is almost common knowledge now, that water is essential for human survival whereby humans would be unable to survive 3-5 days without water. Water makes up about 60% of the human body. It is required in the transport of nutrients to cells and maintaining the blood volume for healthy functioning of the heart. It is also common knowledge that water is composed of hydrogen and oxygen molecules in the ratio of 2:1, respectively. Humans have discovered what exactly water is with regards to its chemical composition, however fascinating questions still remain - water is recycled on Earth, but where exactly does water come from, how did it first come to Earth? Why has water only been found on Earth, not in our neighbouring planets?

3. Grand Issues in Water Management

The biggest issue in water management is drinking water supply to the millions of people living in developing countries. More than 1.2 billion people lack access to clean drinking water out of 7.2 billion people (i.e. about 17% of people living in the world). This is equivalent to 40 times of the current Australian population. It is surprising that even in this age of superior technology, we cannot serve 1.2 billion of our fellow human beings with as little as 5 litres of clean drinking water. Our scientific community and world leaders should take this as one of their gross failures.

The second biggest challenge is death and damage due to flooding. For example, in 2017 alone, flood damage in USA cost the economy about US$ 60.7 billion. Due to climate change, flood severity and damage will increase in the near future. In Australia, between 1852 and 2011, at least 951 people were killed by floods and another 1326 were injured.

The third biggest water related challenge is the lack of water for agricultural use i.e. drought. These costs billions of dollars of damage worldwide every year. Most of the droughts are followed by famine, deaths and displacement.

Another challenge is how to provide clean water to war displaced people who live in camps where there is little infrastructure for the provision of drinking water.

As noted by Rahman (2017), we have done very well in many areas of water resource management, but our failures in certain areas have caused misery to millions of people such as increased salinity due to over irrigation, failure of dam causing deaths and destruction, and water contamination by micro-plastics.

4. Water and Sustainability Education: Example in Literature

Middlestadt et al. (2001) presented a case study on water conservation education in Jordanian schools. This study measured the effectiveness of advising water conservation within homes and the impact of educating students and families to promote water conservation behaviours. The participants were selected at random, where comparisons were made among 671 students in high school in central Jordan, where 424 of the students were 'experimental' and 247 students were the 'control'. The investigated groups consisted of students whom existed in classes where the teachers implemented an interactive curriculum and promoted water conservation practice. The control group, however, did not participate in classes with curriculum implementation but were exposed to lectures about biodiversity issues. The results show that the students involved in the interactive curriculum activities had a higher level of knowledge and understanding about water conservation and demonstrated better water conservation behaviour, more frequently than students within the controlled group.

Blanton et al (2007) presented a case study on the role of school children in the promotion of point-of-use water treatment and hand washing in schools and households in Western Kenya. This study examined the effect of training teachers to promote water treatment and in addition they installed drinking water and hand washing stations in 17 rural schools. They also aided in treating the water by giving schools flocculent-disinfectant powder and hypochlorite solution. They conducted a baseline water handling survey of students' parents from 17 schools and tested stored water for chlorine. They then conducted follow-up surveys and chlorine testing at 3 and 13 months. It was found that parental awareness of the flocculent-disinfectant increased, awareness of hypochlorite remained high, and also household use of flocculent-disinfectant and hypochlorite increased and were maintained after 13 months. Furthermore, the absentee rates of students decreased by 26% after implementation and also a significant increase in household water treatment procedures were also observed.

Laurence et al (2007) presented a case study on the effect of health after promoting schools' approaches to increasing consumption of fruit and water in Australia. The 'Fresh Kids' program formulated an agenda where they concentrated on promoting behaviours related to healthy eating and reducing the risk factors associated with childhood obesity. The objective of the program was to increase fruit and water consumption among school children over a period of 2 years. The study involved four primary schools in the inner west of Melbourne, Australia. Baseline data were collected to assess the frequency of children with fresh fruit, water and sweet drinks, which were either brought from home or bought from the canteen. The lunchbox inspection was repeated continuously for up to 2 years following the program implementation to assess the sustainability of dietary changes. Within all participating schools, increases between 25% and 50% were observed of children bringing fresh fruits. Furthermore, all schools recorded increases between 15% and 60% of children bringing filled water bottles to school and a reduction between 8% and 38% of children bringing sweet drinks were observed. These important changes were present and sustained for up to 2 years following the program implementation.

Higgs and McMillan (2006) presented a case study on teaching through modelling and the experiences in sustainability education. The authors examined how four innovative secondary schools' model sustainable practices to their students. The authors frequently visited the four schools to conduct interviews. Furthermore, they observed daily interactions and reviewed school documents. They found that modelling is an effective approach to sustainability education. The four primary methods in which the schools model sustainability is individual role modelling, school facilities and operations, school governance, and school culture. Other schools interested in promoting sustainability education will likely find these approaches to modelling effective.

Zheng et al. (2018) conducted a study to compare textbooks between China and USA in relation to water education. They noted that when introducing 'water' knowledge, the American edition uses 271 declarative sentences with lots of information covering use, distribution and protection of water resources; however, the Chinese books contains 16 declarative sentences and mainly introduces the nature, distribution and protection of water without much interpretation.
Zhan et al. (2018) presented a case study on developing elementary school children's water conversation action competence in China. In a Shanghai primary school, 69 children (aged 6-8) participated in the water education program for 7 consecutive weeks. The results obtained, based on the 'drawing and telling' approach and pre-survey demonstrated that the participants only have a superficial understanding of water, low awareness of saving water, and limited knowledge of water conservation methods before they joined the programme. After completing the programme, the results show that the children's water conservation knowledge (willingness, self-efficacy, and behaviour) enhanced notably.

The above studies show that water education can be enhanced in schools by adopting specially designed projects. Water Education and Research Committee in Australian Water Association has a number of programs to promote water education in schools and universities in Australia. Water education depends on the status of science education as explained in Rahman et al. (2018).

5. Water Education in Australian Schools

5.1 Curriculum Overview

Australian high school education is based on the Australian Curriculum, Assessment and Reporting Authority. This report will focus on the NSW Education Standards' (NESA) syllabus, providing an overview of water content delivered in NSW

Table 1. Syllabus explaining students' learning requirements regarding water (NSW)

Stage (years)	Syllabus Points
Stage 1 (K-2)	Describe what plants and animals, including humans, need to stay alive and healthy, e.g. food, water and air (page 37) • Identify that some common resources are obtained from the Earth, including soil, minerals and water (page 44) • Share their observations and ideas about the ways that water is used by people in their daily lives (page 44) • Identify some actions which could be taken to care for and use water sustainably, e.g. turning off dripping taps and/or taking shorter showers (page 44)
Stage 2 (3-4)	• Describe some changes in the landscape that have occurred over time as a result of natural processes, e.g. erosion by wind and water (page 55)
Stage 3 (5-6)	• Identify some physical conditions of a local environment, e.g. temperature, slope, wind speed, amount of light and water (page 69)
Stage 4 (7-8)	• (a) Identify that water is an important resource that cycles through the environment (b) Explain the water cycle in terms of the physical processes involved (c) Demonstrate how scientific knowledge of the water cycle has influenced the development of household, industrial and agricultural water management practices (page 109) • Explain that the systems in multicellular organisms work together to provide cell requirements, including ...water...and to remove cell wastes (page 112) • Describe the importance of water as a solvent in daily life, industries and the environment (page 115)
Stage 5 (9-10)	None
Stage 6 (11-12)	**Biology**: • Trace the digestion of foods in a mammalian digestive system, including...water (page 39) **Chemistry**: • Demonstrate, explain and predict the relationships in the observable trends in the physical and chemical properties of elements in periods and groups in the periodic table, including but not limited to...reactivity with water (page 37) • Describe and analyse the processes involved in the dissolution of ionic compounds in water (page 51) • What is the role of water in solutions of acids and bases? (page 53)

schools across the major Key Learning Areas including Geography, History, Science and Personal Development, Health and Physical Education' (PDHPE).

Geography has the largest focus on water education whereby an entire Stage 4 (years 7-8) module is dedicated to water. The module is called "Water in the World" and the content is divided into the topics of water resources, water cycle, Australia's water resources, water scarcity and water management and the value of water. A few examples of specific syllabus points surrounding the topic of water from the Geography syllabus are outlined below:

- "**Space:** the significance of location and spatial distribution, and ways people organise and manage spaces that we live in e.g., water resources.
- **Interconnection:** no object of geographical study can be viewed in isolation, e.g. how people are affected by the environment with regard to use of water on its quality and availability as a resource.

- **Sustainability**: the capacity of the environment to continue to support our lives and the lives of other living creatures into the future, e.g. pressures on the Earth's water resources, the need to manage environments for a long-term future; and sustainable management approaches.
- Students examine water as a resource and the factors influencing water flows and availability of water resources in different places.
- They investigate the nature of water scarcity and assess ways of overcoming it.
- Students discuss variations in people's perceptions about the value of water and the need for sustainable water management.
- Students also investigate processes that continue to shape the environment including an atmospheric or hydrologic hazard such as flood.

Science teaches aspects surrounding water beginning from Stage 1 (K-2) until Stage 6 (years 11-12). Table 1 describes syllabus points students are required to learn regarding water. In addition to direct content related to water, Science in NSW also explores the chemical composition of water, beginning from Stage 4. As of 2019, Stage 6 (year 11-12) Biology is no longer required to teach specific diseases, however teachers often include diseases spread through water.
History has elective topics in Stage 3 (5-6) and 4 (7-8) which explore the social aspects of water. Topics from the syllabus include:

- Stage 3: The diversity and longevity of Australia's first peoples and the ways Aboriginal and/or Torres Strait Islander peoples are connected to Country and Place (land, sea, waterways and skies) and the implications for their daily lives.
- Stage 4: The cultural achievements of the Khmer civilisation, including its system of water management and the building of the temples of Angkor.
- Stage 4: Theories of the decline of Angkor, such as the overuse of water resources.

PDHPE focuses on physical water safety with students in the form of swimming beginning from Stage 1 to 5. Various topics of water safety are also expanded on such as:

- Stage 3: Describe the place of water-based recreational activities in Australian society and how communities come together to enjoy water-based activities.
- Stage 5: Plan and practise responses to emergencies by explaining priority actions and where they may be required to administer first aid, e.g. in and around water.

5.2. **Case Study**

An informal study was conducted where randomly selected school students were asked few basic questions to test their knowledge on water. Ten questions were asked to three age groups, where different groups were asked different sets of questions. The questions can be seen within Tables 2, 3 and 4. The three age groups were 'KG-6', 'grade 7-10' and 'grade 11-12'. The answers provided by the students were marked out of 10 for each question depending on how correct their answers were. This was assessed by the last author, who is a water expert.

Table 2. Questions for KG-6 students

Serial	Questions
1	Where can you find water?
2	Can you drink any water?
3	How do you know when water is not drinkable?
4	What is the main source of water?
5	Can you swim in all types of water?
6	How much time do you spend having a shower?
7	Is water free?
8	Can you drink water in poor countries?
9	What diseases can be caused by dirty water?
10	Why do you need to wash your hand before eating?

Table 3. Questions for 7-10 students

Serial	Questions
1	What molecules are water composed of?
2	Have you heard about the water cycle?
3	Which activity consumes the highest amount of water?
4	What are the dangers of flooding?
5	Where does water from our taps come from?
6	How can we minimise wasting water?
7	How many people in the world have access to less than 5L of water a day?
8	Name 3 diseases caused/transmitted by water?
9	If there were no water taps, where could you get water from?
10	What is the price of tap water in Sydney?

Table 4. Questions for 11-12 students

Serial	Questions
1	What components can water be broken into and how?
2	Do any planets other than Earth have water?
3	How would you access water in the Australian desert?
4	What components can water be broken into and how?
5	How much does the tap water in Sydney cost?
6	Where does toilet water go?
7	How can you save water?
8	What is a flood? How many people die during floods each year?
9	How much damage was caused by the Queensland flood in 2010?
10	What is meant by "drought?" How do droughts affect the Australian community?

Table 5. Results of responses from KG-6 students

Question	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**AVERAGE**
Q1	10	10	10	0	5	10	10	7.86
Q2	10	10	10	10	10	10	10	10.00
Q3	0	5	5	5	0	5	0	2.86
Q4	0	10	10	5	5	10	0	5.71
Q5	10	5	0	10	0	10	10	6.43
Q6	10	10	10	10	10	10	10	10.00
Q7	0	0	10	10	5	10	10	6.43
Q8	10	0	0	10	0	5	0	3.57
Q9	5	5	5	0	5	5	5	4.29
Q10	10	5	10	10	10	10	5	8.57
TOTAL	65	60	70	70	50	85	60	65.71

From our gathered results, we can see that average marks for 'KG-6', 'grade 7-10' and 'grade 11-12' were 65.71%, 43.33% and 47.5%, respectively (seen in Table 5, Table 6 and Table 7). The slight increase of 'KG-6' results compared to the other age groups may indicate that the relative knowledge based on their age group are generally satisfactory. Furthermore, if we analyse the results from Table 5 (KG-6) we can observe low scores for question 3, question 8 and question 9. These questions address the issue "which water is safe to drink". The low average score of these questions indicate that individuals within that age group are unaware of the danger of contaminated water.

Moving on in Table 6 (grade 7-10), it can be observed that the average score is 0 for question 3. This exemplifies that individuals within the age group of 'grade 7-10' do not know which of their home appliances uses the most water. This inadequacy of knowledge can also be seen in the age group 'grade 11-12' where the average of question 9 is '2.5' (seen from Table 7). From this it can be argued that individuals within this age group have little knowledge about the Queensland flood, which was one of the worst floods in our living memory, causing over a $30 billion loss to the

Australian economy. These results indicate that the overall the knowledge of water is not very high within the investigated school students. However, a formal survey is needed involving more schools and a greater number of students to confirm this initial finding.

6. Conclusion

This paper presents an overview of water education in Australia. It has been found that the NSW school curriculum contains water conservation topics quite well; however, mathematical aspects of water science are not covered well. It is important that water is taught at schools at a higher level to make water-educated citizens who value this important resource and so a further group of students take up water education at the university level to become water expert. This will help us to tackle water challenges in a warmer climate more effectively, where water demand will be higher, but water availability will reduce and water disasters will increase in frequency and intensity. Water education will assist to achieve sustainable development of water in Australia.

Table 6. Results of responses from 7-10 students

Question	P1	P2	P3	AVERAGE
Q1	5	5	10	6.67
Q2	10	10	10	10
Q3	0	0	0	0
Q4	5	5	5	5
Q5	0	5	5	3.33
Q6	5	5	5	5
Q7	5	10	0	5
Q8	5	0	5	3.33
Q9	10	0	5	5.00
Q10	0	0	0	0
TOTAL	45	40	45	43.33

Table 7. Results of responses from 11-112 students

Question	P1	P2	P3	P4	AVERAGE
Q1	10	10	5	10	8.75
Q2	10	0	0	10	5
Q3	0	5	5	5	3.75
Q4	0	0	0	0	0
Q5	0	0	0	0	0
Q6	10	10	10	0	7.5
Q7	5	0	5	5	3.75
Q8	5	0	10	10	6.25
Q9	0	0	5	5	2.5
Q10	10	10	10	10	10
TOTAL	50	35	50	55	47.5

7. Acknowledgements

We acknowledge the school students who voluntarily took part in this study.

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