TEACHING MATHEMATICS INCORPORATING VALUES-BASED WATER EDUCATION VIA CONSTRUCTIVIST APPROACHES

Ng Khar Thoe
SEAMEO RECSAM, Malaysia
<*nktrecsam@gmail.com*>

Teoh Boon Tat
SEAMEO RECSAM, Malaysia
<teohbtat@gmail.com>

Tan Khan Aun
Tun Syed Sheh Shahabudin Science Secondary School (TSSSSS), Malaysia
<khanaun@gmail.com>

Abstract

Sustainability issues have ever frequently being made themes at high level talks and conferences. However how far have these issues being practiced at the grassroot level? Sustainability of essential water is such an issue. Science Across the World (SAW), an international web-based learning programme provides an excellent avenue to create awareness among school students, enabling collaboration locally as well as insight sharing globally. A cross-curricular mathematics lesson using the constructivist learning theories was developed emphasizing problem-based learning (PBL) activities. Students' interest in learning mathematics was enhanced with human values inculcated through real life activities. Issues are discussed and possible solutions elaborated. This lesson was introduced to 8 teachers and teacher educators from SEAMEO member countries attending a one month course in SEAMEO RECSAM on online mathematics teaching and learning (6th November to 1st December 2006). Part of the lesson was also piloted among students aged between 12 to 13 years old (in TSSSSS on 29th October 2006), in Regional Training of Trainers (TOT) course on promoting 'Human Values-based Water, Sanitation and Hygiene Education' (HVWSHE) in Southeast Asian Schools which was held at RECSAM from 16th to 25th May 2007. It was later tried out again in TSSSSS between the periods of July and October.

Introduction

Water is a source of life. It is a necessity in life. Without it there is no life. Despite water covering three quarters of the earth's surface, it is ironic that almost 2 million children die every year for want of a glass of clean water and adequate sanitation (UNDP, 2006). One in six people in the world lack proper access to safe drinking water. On the other hand where abundance of safe water is available, wastage is the norm. The United Nations Development Programme (UNDP) has launched a water alert campaign to make a lot more people in the world aware of this issue.

This article elaborates on a cross-curricular mathematics lesson that was devised and implemented with exchange conducted online through Science Across the World (SAW) database (http://www.scienceacross.org) to assist the UNDP achieve its noble mission. Since 1990, Science Across the World (SAW) international web-based learning programme aims to raise awareness of the ways science and technology interact with society and environment. Numerous research conducted based on social constructivist learning theories has revealed that SAW is an exemplary e-learning programme promoting project/problem-based learning (P^2BL) activities. The programme connects almost 6,000 teachers in 132 countries where students collaborate on school science topics through constructive approaches. This initiative inculcates human values in figures and applies these values in real life scenarios making the lesson a challenge in supporting the theme of sustainability of water for all.

Seeing the importance of cross-curricular teaching to redefine mathematics classroom via global P^2BL programme, the first author had devised this mathematics lesson incorporating

human-values via SAW programme. The lesson was introduced to 8 primary mathematics teachers and educators from Brunei, Indonesia, Malaysia, Myanmar, Philippines, Thailand and Singapore, during a one month course entitled "Enhancing online teaching and learning of primary Mathematics teachers" conducted in SEAMEO RECSAM from 6th November to 1st December 2006 and supervised by the second author. Part of the lesson was also piloted among students aged between 12 to 13 years old in Tun Syed Sheh Shahabudin Science Secondary School (TSSSSS) on 29th October 2006 and in Regional Training of Trainers (TOT) course on promoting 'Human Values-based Water, Sanitation and Hygiene Education' (HVWSHE) in Southeast Asian Schools which was held at RECSAM from 16th to 25th May 2007. It was later tried out again by the third author in TSSSSS between the periods of July to October with research findings presented in CoSMEd 2007 on 13th November 2007 (Tan, Ng, Ch'ng & Teoh, 2007).

Constructivism and constructivist teaching

Over the past few decades, constructivism has become increasingly been accepted as a viable theory of knowledge and is replacing the more traditional views that claimed knowledge as a pure entity, unaffected by biological, psychological and sociological contingencies (Roth in McCormick & Paechter, 1999). In the long-established majority traditions, especially in science and mathematics education, the dominant image of teaching and learning has been the transmission mode, from teacher and text to students, of single-track, logically organized knowledge. Whereas, constructivism is defined by Jerome Bruner (1960) as a learning theory in which learning is seen as an active process whereby learners construct new ideas of concepts based upon their current and existing knowledge.

Social constructivism emphasizes how meanings and understandings grow out of social encounters, whereas cognitive constructivism is about how the individual learner understands things in terms of developmental stages and learning styles. *Social constructivist theorists* differ from personal constructivist theories in that they consider knowledge as something that is constructed in social groups and meaning is arrived at by negotiation (Greeno, 1997). Vygotsky (1978) also argued that every function in the child's cultural development appears twice, first in the social level (between people, *interpersonal or interpsychological* and then at the individual level (inside the child, *intrapersonal or intrapsychological*. The following are the key principles of constructivism summarized after the review of literature:

- Learners build personal interpretation of the world based on experiences and interactions.
- Knowledge is embedded in the context in which it is used (i.e. authentic tasks in meaningful realistic settings).
- Create novel and situation-specific understandings by "assembling" knowledge from diverse sources appropriate to the problem at hand (flexible use of knowledge).
- Coaching and scaffolding are two critical components of the "cognitive apprenticeship" model by Rogoff (1990).

The representations of the learning process or instructional/learning strategies in "*Constructivism*" including inquiry/enquiry-based and discovery learning (i.e. guided, less-structured and non-guided discovery) which involve instructional/learning strategies e.g. collaborative learning, *scaffolding*, problem-based learning (that requires putting the students in the context of a problem-based story and students playing an authentic role while investigating and solving the problem. It is sometimes referred to as 'anchored instruction' or 'enquiry-based learning'), authentic learning, etc. (adapted from http://chd.gse.gmu.edu/immersion/knowledgebase/).

With the various instructional approaches incorporated as discussed above, the constructivist ways of teaching were proved to be suitable for students with all levels of academic achievement. Interest in using constructivist views to explain students' learning and teachers' thinking has inspired numerous studies into students' ways of making sense in science and the implications of these for pedagogy. These include research into constructivist views of learning (Osborne & Freyberg, 1985); and a social constructivist approach to reflective teaching (Kim, Ng & Ong, 1998), to name a few. Other studies have focused on the implications of constructivist philosophy of science teaching and students' learning. For example, the Children's Learning in Science (CLIS) model in UK which includes the 5 phases of constructivist teaching approach (CLIS, 1987), and the Learning in Science Project (LISP) at New Zealand that emphasizes on the individual children's understanding of their experience of the world (McMillan & Schumacher, 1997). These studies established the following basic premises of constructivist teaching and learning:

- Students are not empty vessels to be filled up with new ideas by the teacher. They bring to lessons their own ideas about phenomena that are often called 'children's science' or alternative conceptions, and need to be addressed in lessons. To be effective in science learning, the learner needs to 'make sense' of what they learn.
- Learning involves personal and social construction of meaning, i.e. the linking of new ideas with existing ideas and the construction by the student of new meanings. Students construct ideas that are part of the knowledge collectively constructed by the scientific community – a pool of commonly shared ideas.
- Learning involves both the personal and social construction of meaning, i.e. the linking of new ideas with existing ideas. Students construct ideas or new meanings that are part of the knowledge collectively constructed by the scientific community – a pool of commonly shared ideas. Related research was done in CLIS and LISP projects as discussed above.
- Learning is helped if the students are aware of the ways in which they learn and if they are able to monitor their own learning. This is called 'learning-to-learn' or metalearning. Students take more responsibility for their own learning. Thinking skills and study skills are examples of metacognitive skills. Novak, Gowin and Johansen (1983) advocated the use of concept maps as a study strategy and as a record of cognitive structure variables for use in educational research.

Lesson plan illustrating the application of principle/s of constructivism in the classroom with reference to the teaching of a mathematics

(1) Name of the topic: The teaching of mathematics on "percentages, units and mathematical computations" via constructivist, contextual learning and cross-curricular teaching approaches. -

(2) General objectives: This lesson is planned for Primary 6 or Form 1 students who will be introduced to the core learning areas of mathematics subject on "percentages, units and mathematical computation" in relation to facts about water expressed in numbers, percentages and fractions. Various lesson sequences will be delineated incorporating pedagogical content knowledge with the aims to inculcate human values and enhance sustainable water use via problem-solving in daily life.

(3) Learning outcomes: At the end of the lesson, the pupils should be able to:

- define percentage in fractions, figures and written text (e.g. two thirds= 2/3= 66.67% or 66.67/100, three quarter= ¾ = 75% or 75/100, to name a few).
- convert any given fraction to percent and vice versa.

- consolidate understanding on the various units used in daily life (e.g. mm, cm, inches, litres, ml, minute, hours, decimal places, to name a few) especially related to mathematical computation/calculation of water household consumption and water collected from rain or various catchment areas.
- know the percentage of water covering world surface and the amount of water in living things.
- understand the interrelationships of water with all living things in the environment and society with various socio-cultural issues and problems.
- realize the importance to conserve precious water with elicitation and integration of human values (e.g. consideration, quest for knowledge, wise and efficient use of resources, accuracy, caring, concern for others, conservation, team work, sharing, discipline, obedience, initiative, awareness, self-knowledge, cooperation, healthy living, to name a few) related to "Water and Environmentally Sustainable Development".
- do simple project(s) incorporating scientific/thinking/ICT skills to demonstrate understanding of mathematical concepts and manifested inherent human values with exchange of findings globally via web-based learning programme.

(4) Target audience: Primary 6 or Secondary 1 students (ages between 12 to 13 years old)

(5) Prior knowledge: It is assumed that these groups of upper primary or lower secondary students should have obtained the prior knowledge with the understanding of the following mathematical concepts in real life applications as analyzed from the Malaysian primary mathematics curriculum (CDC, 2002; CDC, 2003a; CDC, 2003b; PPK,2001):

(a) "Numbering" in Primary 1, 2, 3, 4, 5 (up to 1 000 000).
(b) "Addition (A),subtraction (S)" in Primary 1, 2, 3, 4 (highest total or within the range of 10 000).
(c) "Multiplication (M), division (D)" in Primary 1, 2, 3, 4 (within 2 to 9 timetables, highest product or dividend of 100 000).
(d) "Time and period" in Primary 1, 2, 3, 4, 5 (with understanding of the relationships between units of time, A, S, M and D).
(e) "Money" in Primary 1, 2, 3, 4 (with A, S, M and D up to RM10 000).
(f) "Fractions" in Primary 3, 4 (with addition and subtraction); also "Relate fractions and decimals to percentage" in Primary 5.
(g) "Decimals" in Primary 4 (with number to 3 decimal places and A,S,M,D until 2 decimal places)
(h) "Understand the relationship between units of time and between units of length" in Primary 5.
(i) "Measure and compare volumes of liquid using standard units" in Primary 5.

(6) Procedure incorporating constructivist approach:

6.1 Proposed steps in the presentation of the lesson with (a) estimated timeframe (b) questions to be asked by the teacher or instructor and (c) learning activities to engage students

Estimated time: 120 minutes (in 3 sessions of 40-45 mins. each with flexible hours allocated for enrichment activities as take home project or Science/Mathematics club activities)

The suggested lesson steps are summarized in Appendix I, including these constructivist phases:

- ***Introductory orientation: identifying prior knowledge with motivational activities*** (***10 mins***)

Teacher will provide an environment which is conducive to the prepared teaching and learning activities to motivate the students' attention (Ng & Ramli, 2003). The activities introduced in this part of the lessons are administering pre-tests; showing world map with constructivist questioning to focus students' attention on two areas covered on earth, i.e. land and water; relating students' experiences in daily life about their awareness on clean and polluted water resources, to name a few.

- ***Elicitation or generation of ideas*** (***10 minutes or mins.***)

Teacher will continue monitoring students' views, to bring them into the open for discussion and evaluation in the light of evidence. Teacher also encourage students to exchange ideas in order to stimulate them towards re-examining their previous ideas (CLIS, 1987 in Ng & Ramli, 2003). In this lesson, teacher will elicit students' prior knowledge in "number, division, multiplication, to name a few" by checking their understanding in calculating the percentage of earth's surface being covered by water. Their ideas on similar calculation will also be re-examined by looking into the percentage of water in human body, as well as other living things converting fractions into percentage, to name a few.

- ***Restructuring of ideas*** (***25 minutes***)

Teacher will take the opportunity to prepare various teaching-learning activities that are suitable for helping the students to clarify and exchange ideas. The students may be exposed to certain situations that challenge or evaluate their ideas, thus help them to construct new idea that are more acceptable and can be understood easily (CLIS, 1987 in Ng & Ramli, 2003). In this lesson, the students will be introduced Science Across the World (SAW) project-based programme, and the activity to calculate water bills (preferably collected from various countries). Students will carry out investigative activities recommended in the SAW programme, record data in the tables as shown in the exchange form with interpretation of findings. They will thus be given opportunities to clarify and exchange their ideas with schools from other countries using SAW database.

- ***Application of ideas*** (***45 minutes***)

Students will be given the opportunity to use their new ideas to solve problems and explain the phenomena related to these ideas, possibly in different contexts. Various investigative and elaborative activities can be created to provide more in-depth studies on the topics to be researched into (CLIS, 1987 in Ng & Ramli, 2003). In this lesson, students will develop various scientific, investigative and ICT skills. Apart from the opportunity given to the students to exchange their findings from investigative activities using SAW database, students in groups will generate ideas to devise projects for water conservation. They need to work out solution to overcome various constraints faced in society coping with the problems of water scarcity, to combat water pollution, to name a few.

- ***Review change in ideas with reflection and assessment/evaluation*** (***30 minutes***)

Students are required to make a comparison of their original and new ideas and to review or reflect on their learning processes. The activities that could be carried out at this phase include making a summary, writing out ideas or opinion, discussing in groups or writing reports (Ng & Ramli, 2003). The closure of this lesson includes teacher giving summary of

lesson via various activities such as providing information from print or non-print materials on how the exemplary organizations had practiced various activities to conserve water and singing the song "WATER: Precious water" to guide students to internalize good human values. Students will have to respond to the questions on testing mathematical concepts as well as post-tests being administered. They may review on their learning outcomes including enhanced values and mathematical understanding.

6.2 Materials to be given to students (e.g. handouts, worksheets, etc.):

(1) World map, colour pencils, Stationeries (e.g. A4 paper, mahjong paper, writing pens, double sided tape, cellophane tape), to name a few.
(2) Sample water bill(s) and examples of how different rate of water tariff is calculated in societies of diverse socio-cultural contexts.
(3) Posters/pictures, educational brochures distributed by NGOs or reusable brochures collected from various sources (e.g. advertisement brochures distributed by supermarket) and print/non-print instructional materials (IMs) to be used as poster presentation or individual portfolio assessment:
   (a) Pictures that depict
      i. scenarios of clean and polluted water;
      ii. water used in activities or settings related to health, sanitation and recreation.
   (b) 3Rs steps for sustainable use and conservation of water with additional project information;
   (c) Information on the effects of water pollution on the environment and health of living things;
   (d) Information on the amount of water content in various living things.
   (e) Activity cards, worksheets and sample answer sheets for graphic organizers illustrating water related issues, e.g.: (i) fishbone diagram; (ii) concept map labels and exemplary concept map depicting water cycle with various related phenomena.
(4) Worksheet with mathematics questions.
(5) Audio visual aids (AVAs) (e.g. OHP, transparencies, to name a few), ICT equipment or software, e.g. pH meter, Geographical Information System (GIS), data logger, computer with powerpoint presentation facilities and Internet URLs for:
   (a) web-based learning programmes, e.g. "Science Across the World" (SAW) with downloaded exchange form (http://www.scienceacross.org) for compilation of class findings (Appendix II);
   (b) "concept mapping" via Inspiration software trial versions (http://www.inspiration.com).

(6) Lyrics of song "WATER: Precious water" with composed musical notes in the form of music or audio files available at http://www.srecsam.edu.my/elearn/ (Appendix II).

(Verse 1) **W**ater can be **A**vailable from **T**he **E**veryday's **R**ain,
Everyday's Rain, Everyday's Rain,
Water can be Available from The Everyday's Rain, We ***can reuse*** clean water.

(Verse 2) **W**ater will flow **A**way **T**hrough **E**very **R**iver,
Every River, Every River,
Water will flow Away Through Every River, We ***should not pollute*** water.

(Verse 3) **W**ater will be **A**bundant if we **T**ry **E**ntice **R**ecycling,
Encourage Reusing, Ensure/Enforce Reducing,

Water will be Abundant if we Try Entice Recycling, We ***must conserve*** water.

(Verse 4) **W**ater forms **A** major part with **T**hreequarters of **E**arth's **R**atio,
Threequarters of **E**arth's **R**atio, **T**hreequarters of **E**arth's **R**atio
But only one percent is fresh to be shared by all living things,
So WATER is ***very precious***.

(7) Evaluation

(1) Assessment on knowledge or skills on Mathematical concepts via calculations or Q&A whereby students are expected to give examples from their own experience:

1. (a) About three quarter of the earth's surface is covered by water. What percent is it?
   (b) 7/10 of our brain is water. What percentage is it?
2. 97% of the water on earth is salty and 2% is ice. If the remaining is fresh, what percent is it?
3. The average daily consumption of a family is 500 litres of water, out of which 100 litres is used for watering the garden. 100 litres for cooking and drinking. 200 litres for washing and sanitation purpose and the rest is wasted. What percentage of the daily consumption of water is used?

(2) Assessment on manifested human values:

1. Questions and answers in (a) class activities and/or (b) Pre-/post-test questionnaires.
2. Observation checklist on desirable human values to be inculcated and classroom activities.
3. Output of students' learning, e.g. students' worksheet/portfolio, journals, SAW exchange form, graphic organizer e.g. concept maps, to name a few.
4. Students' ideas on designing project to reflect the three pillars of ESD, i.e. "Environmental, Social and Economical" concerns.

Conclusion

Integrating a cross curricular lesson into the classroom has been found to add value to seemingly isolated disciplines. Mathematics has been found to become alive and purposeful. Students found meaning in what they learnt. And what they found from their learning not only affects their own lives but also the lives within their community, throughout their country and across the world. And there can be fun too with the rendering of a theme song! Water, or any other natural essential resources, which are usually taken for granted, can well be appreciated by incorporating human based values into lessons across disciplines. Science Across the World provides not only an excellent platform for this integration but also enables far reaching effects, for a better sustainable world.

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Summary guide of lesson steps or implementation processes: **Appendix I**

Time Frame	Process/ Procedure	Activities and/or Question(s) posed with possible answer(s)		Strategies/Approaches and Thinking skills	Materials/ Teacher aids
		Teacher	Pupils/Students		
10 mi-nutes (mins.)	**Introductory orientation with motivational activities**	Teacher to administer pre-tests; then to show world map and raise discussions: • What have you observed on the earth as shown in the map?	Pupils were to respond to pre-tests; then to observe, interact and respond with possible answers: • Different colours, land (multi-colours) and water (blue colour)	*_**Identifying prior knowledge**_, values and attitudes *_**Constructivist** questioning techniques_ *_**Constructivist** cross-curricular approach (relating students' knowledge in Geography, Language/Arts, Science/Maths)_ *Scientific/Mathematical skills (observing, communicating, estimating) *Thinking skills ('elaboration' with examples) in responding to open-ended questions *_**Contextual** teaching and learning (CTL) relating or sharing daily experiences_	-Pre-test -World map or globe - Colour pencils (optional if students cannot recall the name of colour learnt) -Posters/pictures of clean and polluted water (optional)
	1. Estimating areas covered by water on the earth	• Which do you think is larger - the total areas shaded with multi-colours (land) or the area shaded in blue (Sea)? • Can you estimate how many times the area covered by sea as compared with the area covered by land?	• Blue colour (sea). • Blue colour (sea) is two or three times more than the areas shaded with multi-colours (land).		
	2. Identifying possible water resources and environmental pollution	• Apart from water in the sea, where can we find water? • Which sources contain clean, drinkable and usable water? Which sources are polluted?	• Rain, river, tap water, mineral water, drainage, lake, pond, fish tank, dams, to name a few. • Drinkable water: mineral water Usable water: rain, clean river Polluted water: drainage, river near industrial areas, to name a few.		
Guided Instructions		Teacher to raise discussion:	Pupils/students were:		
10 mins.	1. Calculating the percentage of water: *on the earth and	• Your estimation is almost correct. About three quarter of the earth's surface is covered by water. What percent is it?	• To possibly give answer as 75% [Note: Teacher will guide the calculation "Three divided by four (3/4) times 100%" if students are unable to respond]	*Less-structured guided mathematical calculation with ***elicitation of students' prior knowledge*** in "number, division, multiplication, to name a few"	- MS calculator or simple cal-culator, mathe-tical symbols (optional)

Time Frame	Process/ Procedure	Activities and/or Question(s) posed with possible answer(s)		Strategies/Approaches and Thinking skills	Materials/ Teacher aids
		Teacher	Pupils/Students		
	*in living things	• About 2/3 of human body is made up of water. What percent is it? [Note: Some literature stated human body consists 72% of water]	• To possibly give answer as 66.67% (two thirds or 2/3 times 100%).	**Constructivist* ***Constructivist*** *questioning and elicitation of responses*	-Pictures of human body and other living things
		Teacher to further show the pictures of various living things with the amount of water content, e.g. tomato (95%), water melon (96%), liver (70%), olive oil (1%), cow milk (86%), to name a few.	• To colour the pictures of living things with different percentage of water content; • To appreciate the importance of water that forms the major components of living things.	**Constructivist* ***Constructivist*** approach via relating students' experience in daily life incorporating cross-curricular approach (Mathematics, Arts, to name a few).	-Pictures of living things with percentage of water to be coloured in blue -Colour pencil
25 mins.	2. Introdu-cing SAW database, calculating daily water use (compa-ring with percentage) via checking with under-standing of the monthly water bill received at home	Teacher to: • demonstrate web-based on-line exchange programme • download SAW exchange form on "*Water, Precious Water*" and assign students working in groups to: * conduct survey and record data in ***Table 1*** and ***Table 2***; * calculate the percentage of water use for each activity; • show an example of water bill received at home and guide students' understanding to interpret water bill.	Pupils/students in groups to: • understand via hands-on activities the procedures of SAW project-based programme; • carry out survey(s) to find out: * water use in a week at home and in school (***Table 1*** and ***Table 2***). * the percentage of water use for each activity at home and school. • understand and interpret water bill, e.g. "Amount of water use (in litre)= Meter reading ('y' in present month)-Meter reading ('x' in previous month)= z litre".	*ICT skills (e.g. surfing the Internet, downloading exchange forms, uploading class findings onto SAW database, and so forth) *Scientific skills (observing, communicating, collecting and recording data, interpreting data, carry out investigations/surveys, and so forth) *Constructivist contextual learning (relating students' prior knowledge, e.g. subtraction to calculate water use per month, to name a few)	- SAW website with downloa-ded exchange form on "Water, precious water" - ***Table 1*** and ***Table 2*** for calculation of daily water use [Downloadable from http://www.scienceacross.org.]
15 mins.	3. Recording findings on exchange forms,upload	Teacher to: • guide group's discussion and consolidation of class findings on exchange forms, and	Students to: • work in groups to compile group discussions into class findings;	*ICT skills (e.g. surfing the Internet, downloading exchange forms, uploading	-Completed students' class findings in ex-change forms

Time Frame	Process/ Procedure	Activities and/or Question(s) posed with possible answer(s)		Strategies/Approaches and Thinking skills	Materials/ Teacher aids
		Teacher	Pupils/Students		
	onto SAW database	upload onto database.	• upload exchange form on "Water" onto SAW database.	class findings onto SAW database, and so forth)	-Internet
15 mins.	4. Brainstor-ming of ideas for simple global maths project	Teacher to: • stimulate students' discussion to brainstorm ideas for simple global maths project with cost saving measures, recycling of water, etc.	Pupils/students in groups to: • generate ideas to devise projects for water conservation; • appreciate the need for creative solutions in overcoming constraints faced in society of scarce water use.	*Thinking (critical/creative) skills in responding to open-ended questions *Cooperative group problem-solving	- Stationeries (e.g. mahjong paper, writing pens, to name a few)
15 mins.	5. Presenta-tion of group's ideas e.g. on various projects to conserve water	• Teacher to organize group presentation. • Teacher to also stimulate student' interest to think of more challenging project topics or alternative methods. Possible areas of interdisciplinary and more challenging project ideas working with students of higher grade levels, e.g.: * Developing prototype to combat water pollution * Recycling polluted water into usable/drinkable water	• Possible areas of simple project ideas that may be obtained: * Making a simple rain gauge to collect and calculate the amount of rain water or acid rain (which can be further tested on its pH) * Design technology for rain water harvesting to reuse/conserve water * Tracing the daily amount of water used in house and school, identifying "measures to use water sustainably" and recording "amount of water use each month with different safe water use practices" via tables and illustra-tive graphs on the data collected	*Cross-curricular approach (Science, Mathematics, D&T) *Scientific skills (observing, communicating, recording data, graphing, investigating, to name a few) *Project/problem-based learning (PBL) with students working in Community of Practice (CoP) guided by More Knowledgeable Others (MKO), e.g.teacher(s), peer group(s) of higher grades, research scientists, to name a few. *Education for Sustainable Development (ESD)	- Stationeries (e.g. mahjong paper, writing pens, etc.) - Computer with powerpoint presentation or Audio visual aids (e.g. Transparencies and OHP) for presentation of group discussions - pH paper/meter (optional)
	Closure				
10 mins.	1. Summary of exempla-ry practices for	Teacher to: • summarize the exemplary practices for "water	Pupils/students to: • internalize the good human values including sustainable use and	*Interactive discussions *Educational brochures	- Stationeries (e.g. mahjong paper, writing

Time Frame	Process/ Procedure	Activities and/or Question(s) posed with possible answer(s)		Strategies/Approaches and Thinking skills	Materials/ Teacher aids
		Teacher	Pupils/Students		
	"conser-vation of water"	conservation" as discussed today.	conservation of water.	distributed by NGOs *Values-based water education	pens, etc.) (optional)
	2. Singing song "WATER: Precious water" that is related to 3Rs with the importance	Teacher to: • remind the importance of precious water (Verse 4); • explain the lyrics and lead the song on "WATER: Precious water" to be sung together with students;	Pupils/students to: • understand the need to conserve scarce and essential resources such as water; • understand the meaning of lyrics and sing the song together;	*Cross-curricular approach (Social Studies, Music, Language, Science, Health and Environmental Education, Geography, ESD)	-Lyric of song (possibly in music file with singing)
	to conserve and prevent water pollution	• encourage sustainable use of water via 3Rs (i.e. Reduce, Reuse, Recycling) using educational posters by recalling "Verse 1 and 3" • recall "Verse 2" of the song and highlight "the source and effects of water pollution on the environment and the health of living things" if human beings were to pollute river water.	• gather information from the print or non-print materials on how the exemplary organizations had practised various activities to conserve water; • understand and realize the importance to conserve and prevent from water pollution due to its characteristics as universal solvent; • internalize good human values and sustainable use of water.	*Multiple intelligences (musical/rhythmical, to name a few) *Cooperative group work and CTL modelling exemplary practices of water conservation used by various organizations. *Cross-curricular approach (Music, Science, Health and Envi-ronmental education, Education for Sustainable Development) *Multiple intelligences (musical, intra/interpersonal, to name a few)	-Posters, print/ non-print instructional materials (IMs) on "3Rs steps for sustainable water use or conservation" -Posters, pictures or IMs on the effects of water pollution on environment and health of living things
	Assessment/ Evaluation				
20 mins.	1. Assessment of students' understanding	Teacher to: • assign students to work either individually or in groups to	Pupils/students to: • work individually or in groups to compile pictures with texts or writings	* Thinking (critical/creative) skills [use of graphic organizers (e.g. fish bones, main idea tables,	-A4 paper, pens -Concept map labels, cellophane

Time Frame	Process/ Procedure	Activities and/or Question(s) posed with possible answer(s)		Strategies/Approaches and Thinking skills	Materials/ Teacher aids
		Teacher	Pupils/Students		
	and attitudes to conserve water	"illustrate the cause and effect of water pollution" using portfolio, graphic organizers or concept maps; • administer post-tests to assess students' enhanced values/attitudes for sustainable use of water.	on various possible sources and effects of water pollution on the environment and the health of living things, either in portfolio for assessment, graphic organizers or concept maps; • respond to the post-tests administered individually.	attribute wheels, etc.) or concept maps to illustrate understanding on "cause and effects of water pollution"] * Individual/group portfolio alternative assessment *Survey questionnaires	or double sided tapes and mahjong papers -Inspiration software -Observation checklist -Post-test
	2. Assessment on knowledge or skills on Maths concepts	Teacher to: • distribute worksheet to assess students' mathematical understanding.	Pupils/students to: • work individually to respond to the questions on testing of mathematical concepts.	*Mathematical calculations, Interactive question and answer sessions	-Questions and answers Mathematics worksheets

Appendix II

Global Mathematics Project

(Adapted from "Science Across the World" topics on "Drinking Water" and "Acid Rain")

Water, Precious Water

TO:

Date	6/11/2006
Teacher's name	Mr. Tan Khan Aun (for Mathematics) OR Ms. Linda Toh (for Science)
Student's name(s)	
School	Tun Syed Sheh Shahabudin Science Secondary School (SMSTSSS) OR SMKA Al-Mashoor(L)
Address	Jalan Damai, Bukit Mertajam, Pulau Pinang 14000 Malaysia OR Jalan Air Itam, 10460, Penang.
Phone numbers (inc. dialling code)	Telephone: 604-5305636 OR 604-2296790 Fax: 604-5380853 OR 604-2291503
E-mail address	tankhanaun@yahoo.com.my OR smkaalmashoorl@yahoo.com
School website address	http://smstsss.net/

We understand that your class is studying "*Water, Precious Water*". We would like to exchange information about water resources and analysis of water (using mathematical units and calculation) with its importance in relation to how it affects your lifestyle and health in the environment and society. We enclose the opinions of our class with this exchange form.

We look forward to hearing from your class. Please reply.

FROM:

Teacher's name	Mr. Teoh Boon Tat OR PM-2233 participants
Student's name(s)	
School	SMK Teknik OR RECSAM school Malaysia
Address	Jalan Sultan Azlan Shah, 11700, Penang, Malaysia.
Phone numbers (inc. dialling code)	Telephone: 604-6583266 Fax: 604-6572541
E-mail address	teohbtat@gmail.com, recschmas@yahoo.com, ssysrecsam@gmail.com
School website address	http://www.recsam.edu.my and http://www.srecsam.edu.my/elearn

(A) Water Resources

1. a) The main water resources in our country or region are:
dam, reservoirs, rivers

b) Where we live, we use these water resources:
dam, reservoirs, wells, rivers

[Note *(We have also collected the following useful information related to water in our visit to Water Treatment Plant in 2005):*

(1) The sources of natural water are waterfall, river, ice and snow, lake, well, pond, rain, oasis, sea, spring. There is more water than any other liquid on the earth surface. Some parts of the earth are covered by ice and snow. These include high mountains and the areas near the poles. Water is also found in the atmosphere as water vapour. Tropical rain forests have a damp atmosphere.

(2) We can survive up to a month without food but only 5-7 days without water. A tomato is 95% water. A cow must drink four gallons of water to produce one gallon of milk. About two thirds of the human body is made out of water. 70% of our skin is water. Every system in our body uses water and it is important because it makes up 83% of our blood, transport body wastes, lubricates joints and keeps our body temperature stable. It is also a part of cells, which make up all living things.

(3) Although 75% of the earth's surface is covered by water, mainly by oceans. Out of the 3% of the earth's water is fresh water and can be drunk, but:

(a) 99% of the water in the world is salt water or frozen water. This leaves only 1% of fresh water to be shared by all living things, including human beings. OR

(b) 97% is salt water found in the oceans which cannot be drunk. Another 2% of the water found on earth is frozen in glaciers of the North and South Poles, and that leaves us with about 1% of fresh water to be shared amongst all living things on the planet. That's why water is so precious.]

2. a) Where we live, it rains at these times of year:

Throughout the year, but more often in April and October, with the occurrence of the annual southwest (April to October) and northeast (October to February) monsoons.

[Note: We understand that there are 12 months per year, i.e. January, February, March, April, May, June, July, August, September, October, November, December]

b) In a year, our total rainfall or the average rate of annual rainfall is quite high, i.e. about 25 000 mm (250 cm or 100 inches)

Malaysia enjoys the tropical climate with plenty of sunshine and rainfall throughout the year. Temperatures typically range from 70 to 90°F (22 to 33°C) and cooler in the highlands. Much of the rainfall is concentrated in the late afternoons and humidity is high throughout the year.

3. a) Our drinking water comes from:

☒ A tap connected to the mains water supply ❑ A river
☒ Bottles of mineral water from shops ❑ A lake
❑ A spring ❑ A rain water tank
❑ A well ❑ Others: rainfall, our school and house.

b) The places where livestock drink are:

In town, domestic pets/poultry drink tap water.

In the countryside, the farm animals or household poultry drink water from the wells, rivers and tap water as well. People living in the jungles may drink water from various sources, but they should be aware of the health and safety aspects of the drinking water.

4. a) In our region, the situation about water shortage is:

Where we live, there is no water shortage at the moment. However, during the dry months (January-March), water in the dams is usually greatly reduced.

b) This is how often our water is rationed or limited:

Very rarely water is rationed. During repair of roads, pipes, etc., notices will normally be sent to houses for the temporary cut of water supply.

5. Conserving water resources by "reducing, reusing, recycling" precious water:

a) These are examples of the ways in which people reduce or re-use water:

- Ration or limit water use at particular time
- Re-use rainwater to wash car

b) These are examples of the ways in which people recycle water:

- Recycle water from washing to water plants, flush toilets, clean five-foot way/corridors/drains, etc.
- Recycle water from washing rice, fish or meat to water plants (which is believed to act as fertilizer including urine).
- Converting seawater into drinkable water by desalination
- Recycling polluted water into usable/drinkable water via scientific/technological project e.g. use of composite water filter, etc.

(B) Analysis of Used Water, Drinking Water and Rain Water

6. Analysis of Used Water

a) The estimated amount of water used in a home is: _836_ litres a day.

(Note: It was estimated as 25,080 litres/ 30 days for June 2005, or about between 200 to 1,000 litres a day)

b) We could make a rough estimation of water use in a week at home or at school using the following tables:

Table 1: Water use in a week (at home)

	Water use	Litres (estimation*)	Times each day in a 7-days' week							Total time used	Total
			1	2	3	4	5	6	7		
1	Flushing toilets (per use)	15									
2	Washing hands (per minute)	19									
3	Drinking (per minute)	19									
4	Shower (per minute)	10									
5	Brushing teeth (per minute)	19									
6	Bath (per use)	150									
7	Cooking (per minute)	19									
8	Dishes (per minute)	19									
9	Washing clothes	150									
10	Washing car (per hour)	950									
11	Garden hose (per hour)	950									
12	Others, please state:										
	Total Estimated Weekly Water Use										

* This calculation could be replaced by your own measurement using a measuring jug or any of your own measuring device.

Table 2: Water use in a week (at school)

	Water use	Litres (estimation*)	Times each day in a 7-days' week							Total time used	Total
			1	2	3	4	5	6	7		
1	Flushing toilets (per use)	15									
2	Urinal (per use)	10									
3	Hand basins (per minute)	19									
4	Taps (per minute)	19									
5	Lawn watering (per hour)	950									
6	Shower (per minute)	10									
7	Others, please state: Washing clothes (hostel inmates)										
	Total Estimated Weekly Water Use										

* This calculation could be replaced by your own measurement using a measuring jug or any of your own measuring device.
[**Adapted from** UN-HABITAT, SWD & SIDA (2005). Water Audit – Quality and Quantity. United Nations Human Settlement, Swedish Water Development and Sida.]

7. Analysis of Drinking Water

a) We estimate that a single student drinks about 1.5 litres a day of tap water.
(Note: including in coffee, tea and other drinks including tap water).

b) We estimate that a single student drinks about 1 litre a day of bottled water.
(Note: We understand that 1 mineral water bottle is about 500 or 1000 ml)

c) The pH of our drinking water at school is : 8.22

The pH of our drinking water at RECSAM is : ____

(Note: The reading of pH is recorded up to 2 decimal numbers)

d) The concentrations of impurities are:

lead ions, Pb^{2+} : < 0.05 mg/L or < 50 μg per litre
nitrate ions, NO_3^- : <10 mg/L or < 10 000 μg per litre
pesticides : between < 0.00003 to 0.02 mg per litre

(Note: We know how to convert or calculate from one unit to another.
E.g. 1L = 1000 mL or ml or millilitre,
1mg = 1000 μg, so 0.05mg = 0.05X1000 = 50 μg.)

e) The hardness of the water is:
☒ low (*about 33mg/L*)
❑ medium
❑ high

"Hardness" (*keliatan*) is the amount of dissolved calcium and magnesium in water.

f) The number of coliform bacteria is 0 or less than 1 per 100ml in our local water supply.

By right it should be 0 per 100 ml to be safe for drinking. But raw water which is not safe to drink will normally have coliform bacteria. The test for coliform bacteria will take about 24 to 48 hours, or 3 to 5 days, and was normally conducted in the Chemistry/Health Department. Water contaminated with coliform bacteria will turn the colour of indicator from purple to cloudy greenish/purplish things with gas floating on top of the solution (*traditional technique*) OR showing the reddish or purplish patches in the sampling culture which was put inside and oven with 37°C (to reactivate the bacteria) before the testing for about a day (*new technique*)

[Note: We know that there are 24 hours in 1 day]

g) Impurities that exceed the EU guide level for drinking water are:

N/A. Our drinking water at school and housing areas contains no substance exceeding the Ministry of Health (MOH) standards which are in accordance to World Health Organization (WHO). It was proved to be safe to drink after water testing was done in Water Treatment Plant (WTP), Botanical Garden, Penang.

During our visit to WTP, we have recorded the following information using mathematical units and our understanding of mathematical concepts on "year, length, decimals, structure, volume, percentage, etc."

* The Vision of WTP : Meeting all your water supply needs

* The Mission : WTP will be the leading organization in water expectations

* History of WTP : It was built on 1892 with 232 feet, depth 32m, tall 300m
reconstructed in 1950 by J Mac Ritchie, A.M.I.C.E.

* There are two sedimentation tanks, total area of sedimentation tanks (excluding inlet and outlet channel) 390m^2.

* There are three filter beds, with area of each filter bed 31m^2 and total area of sedimentation filter beds 93m^2.

* The design (maximum) plant capacity is 18,200 m^3/day or 18.2 million litres of water a day and the rate of filtration is 125 l/m^2/min. The number of reservoirs/ capacity/ level is 1 no./ 22,000 m^3 TWL: 70.87 m, FL: 61.72 m

* The raw water source is Sungai Air Terjun which flows downhill from Penang Hill. The delivery pressure is 70.87 m. The river "delivers" water from the verdant and refreshing Waterfall and Highlands Catchment Areas.

h) In our country the drinking water guide levels are:

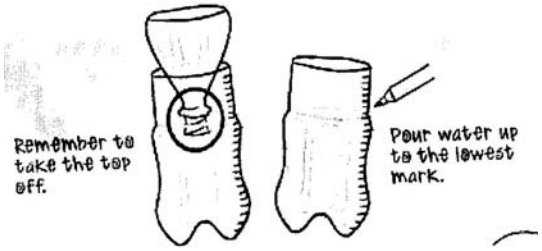
❑ the same as the EU

☒ the same as the WHO or Ministry of Health (MOH)

8. Analysis of Rain Water

a) This is how we collect data and analyze acid rain.

- First, we design a simple device as rain gauge to collect rain water (see Figure):
  - Collect some plastic mineral water bottles (500 ml or 1000 ml).
  - Measure about 10cm (for 500 ml bottle) or 20cm (for 1000 ml bottle) from the top of the bottle and mark this with the pen.
  - Using the scissors carefully cut off the top of the plastic mineral water bottle.
  - Turn the funnel upside down and slide it into the top of the plastic bottle to ensure it is a tight fit, thus help preventing the water inside the plastic bottle from evaporating.
  - Use the ruler to mark the scale, e.g. 5mm sections from the base of the plastic bottle to the top. Pour water up to the lowest section.
- Then we find a suitable place for the rain gauge, away from trees and buildings, where no one accidentally will kick it over. Leave the bottle to collect rain water.
- The acidity of rain water which was collected will then be analysed by either pH paper or a pH meter.



b) The pH of rain water falling near to our school is : 5.58

(Note: The reading of pH is recorded up to 2 decimal numbers)

c) These are the main sources of acid rain in our town or country.

- In many homes there are often two or more cars. With more and more cars used by people in our town, there will be higher frequency in traffic or automobiles on our roads with emission of fuels by car exhausts.
- The burning of fossil fuels by factories in the industrial areas where we live result in gases like SO_2, NO_x released out of their chimneys.
- Homes burning rubbish results in the release of harmful gas into the atmosphere.
- Power plants, heating systems, means of transport and industrial plants or industries burning things that let harmful CO_2 into the atmosphere.

d) These are the main environmental problems caused by acid rain in our country.

a. High level of degradation of forests (especially forests in high mountain regions which are exposed to more acidic clouds and fog that are more acidic than rainfall) and vegetations are being destroyed by the acid rain, thus causing the greenhouse effect.

b. Fish and wildlife in rivers and lakes are dying because the acid rain is making the water to be too acidic and poisonous for aquatic life.

c. Some monuments are damaged because they are made of $CaCO_3$. Some of the old buildings and statues are made of limestone structures and marble, which are very easily eroded by acid rain. Corrosion damages at buildings are accelerated at a quick pace.

d. The ground, the ground-water and the inland waters will get acid.

e) This is what is being done in our country to try to solve the problems of acid rain.

a. TV advertisements to make people more aware of the environment and encouraging people to recycle their rubbish, to use smokeless coal, less burning of fossil fuels (e.g. petrol, coal, turf, oil) to produce electricity, etc.

b. Inform young people and have constant education about solving the problems of acid rain and constant monitoring of pH value of rain, soil and surface waters in our school.

c. Practising the habit of taking more public transport (e.g. buses, taxis, trams, trains, etc.), walking, cycling or carpooling (i.e. sharing journeys with others going to school or work, e.g. parents could take turns to drive their children to school). This could help cutting down the amounts of CO_2 emissions from cars.

d. Building cars with catalyst and power stations with filter equipment. Heavy industries have had to install special equipment to remove sulphur dioxide and nitrogen dioxide from the fumes they produce. Filters such as “scrubbers” are put on fabrics chimneys of the factories to filter the air that comes out. Factories and industries now have to install catalysers to filter all their emissions, thus to stop the emission of nitrates and sulphates into the atmosphere.

e. The government has also imposed various regulations, e.g. introduce higher taxes on coal, introduce speed limits on motorways, impose restrictions on use of petrol, i.e. all the companies now have to sell lead free petrol, also to reduce the amounts of sulphur in their products to reduce the amount of sulphuric acid in the rain.

f. Speed limit on the roads or highways to be reduced as slower cars will produce less exhaust fumes. Cars and other automobiles also have catalysers installed for filtration of toxic gases. The suburb traffic must also be promoted.

g. To live more environment-friendly, e.g. use less energy or use natural energies (solar, wind, geo-thermal energy) in more cases to burn less fossil fuels, recycle our rubbish, etc.

h. To improve heating systems in the houses.

i. To investigate more in environmental products.

j. To find global agreements and look for global solutions.

(C) Water and Health in Society and Environment

9. Drinking water affecting health in society and environment

a) Our main water supply is: ☒ safe to drink

❑ not safe to drink

We know this because:

We have visited out local Water Treatment Plant (WTP) and the officer had tested the drinking water we brought and performed the water analysis. We were also told that WTP had conducted regular monitoring of the quality of water (as required by the Chemistry/Health Department) to ensure that our water supply is safe to drink. We drink tap water everyday and we are in good health so far.

b) Before we drink water from our main water supply we:

❑ do not treat it ☒ filter it (sometimes)

❑ leave it to stand ☒ boil it

❑ treat it chemically ☒ it comes treated

❑ other : Sometimes we leave the tap to flow for a while as the water looked cloudy or dirty when it started to flow from the tap.

c) The statement which best describes what people in our community know about the quality of their drink water is:

☒ They do not question the quality of their drinking water.

❑ They are aware that drinking water contains impurities, but have no idea what they are.

- ❑ They are aware that drinking water contains impurities and can name at least one of them.
- ❑ They are aware that drinking water contains dissolved substances and can name several of them and their possible effects on health.

d) (i) People are particularly worried about these dissolved substances or micro-organisms in drinking water:

Most people think that the tap water has bacteria or microorganisms and dissolved substances. However, they are not too worried about any dissolved substances as they think our drinking water is safe to drink. As long as they filter and boil the water before consumption, it is considered safe to drink.

(ii) Commonly found examples of water-borne diseases which affect people in our country are :

E.g. encephalitis, malaria, cholera, diarrhoea, yellow fever, malaria, JE&Nipah virus, river blindness (onchocerciasis), vomiting, bilharzias (or schistosomiasis), hepatitis, dysentery, stones in the kidney, etc.

10. Acid rain affecting lifestyle including health in society and environment

(a) The effects of acid rain that people worry about are:

- It kills fish, plants and trees, thus decreases the amount of food. The plants and the animals are injuried and will die out.
- The main problems are that acid rain is destroying the land and is making the soil too acidic to farm effectively.
- It is also destroying the crops making the quality less, also indirectly affecting the economy of the country.
- Damages at medieval buildings built of sandstone. In addition, tourism was also affected as some of the buildings made from limestone are turning black due to acid rain reacting with the limestone, making the city look dirty and not attractive.

(b) The effects of acid rain on health in the environment and society:

- Acid rain has caused the rise of illness of the respiratory system and of allergies or the increase of the incidence and severity of health problems.
- The release of Nitrogen Oxide has an impact on human health. Ozone is one of the sources of many illnesses such as asthma and emphysema.
- Acid rain has also led to an elevated relationship between illness and premature death from heart and lung disorders, such as asthma and bronchitis

Appendix III

WATER: Precious water

4/4 C Major

Verse 1

C | 1. 1 1 1 1 1. 1 3 3 3 | **W**a-ter can be **A**- vai- la- ble from **T**he
C | 5. 5 5 3 --- | **E**- very- day's **R**ain,
G | 4. 4 4 2 --- | E- very day's Rain,
C | 3. 3 3 1 --- | E- very day's Rain,

C | 1. 1 1 1 1 1. 1 3 3 3 | Wa-ter can be A- vai- la- ble from The
C | 5. 5 5 3. 3 | E- very- day's Rain, We
G | 4 4 2 3. 3 | can re- use clean wa-
C | 1 --- . --- | ter.

Verse 2

C | 1. 1 1 1. 1 3. 3 | **W**a- ter will flow **A-** way **T**hrough
C | 5. 5 5 3 --- | **E**- very **R**i- ver,
G | 4. 4 4 2 --- | E- very Ri- ver,
C | 3. 3 3 1 --- | E- very Ri- ver,

C | 1. 1 1 1. 1 3. 3 | Wa- ter will flow A- way Through
C | 5. 5 5 3. 3 | E- very Ri- ver, We
G | 4 4 2 . 2 3 | should not pol- lute wa-
C | 1 --- . --- | ter.

Verse 3

C | 1. 1 1 1 1 1. 1 3 3 3 | **W**a-ter will be **A-** bun-dant if we **T**ry
C | 5. 5 5 5 5 3 --- | **E**n- tice **R**e- cy- c- ling,
G | 4 4 4 4. 4 2 --- | En- cou-rage Re- u- sing,
C | 3. 3 3. 3 1 --- | En- sure Re- du cing,

C | 1. 1 1 1 1 1. 1 3 3 3 | Wa-ter will be A- bun-dant if we Try
C | 5. 5 5 5 5 3. 3 | En- tice Re- cy- c- ling, We
G | 4 4 2 3 | must con- serve wa-
C | 1 --- . --- | ter.

Verse 4

C | 1. 1 1. 1 1. 1 3 3 3 | **W**a-ter forms **A** ma-jor part with **T**hree-
C | 5 5 5 5. 5 3. 3 | quar-ters of **E**arth's **R**a- tio, Three-
G | 4 4 4 4. 4 2. 2 | quar-ters of Earth's Ra- tio, Three-
C | 3. 3 3 3 3 1. 1 | quar -ters of Earth's ra- tio, But

C | 1. 1 1. 1 1. 1 3 3 3 | On-ly one per- cent is fresh to be
C | 5 5 5 5. 5 3. 3 | shared by all li- ving things, So
G (1 octave lower) | 4 4 5. 5 7. 7 | WA- TER is ve- ry pre-
C | 1 --- . --- | cious.

Lyrics and song: Ng Khar Thoe
Music compilation: Ng Chong Khai