Making Meaning out of Learning the Rise of Applied Learning

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- Paper Presentation PAP336

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- This presentation can be found online at…

www.scientist.sg

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School of Science and Technology, Singapore

- The School of Science and Technology, Singapore (SST) is a specialised independent school with a cohort of *ca*. 800 students. Entry to SST is through Direct School Admission.
- SST offers a 4-year programme that focuses on science and technology delivered through an applied learning framework.
- Apart from a sound broad based academic curriculum, SST also offers four *applied subjects*, namely Biotechnology, Fundamentals of Electronics, Media Studies and Design Studies.
- As a “Future School”, SST leverages Information Communication Technology (ICT) pervasively to enhance the learning environment of its students.

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LEARNING IN A WHOLE NEW WAY

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- Singapore has a world class education system that it must continue to invest in.

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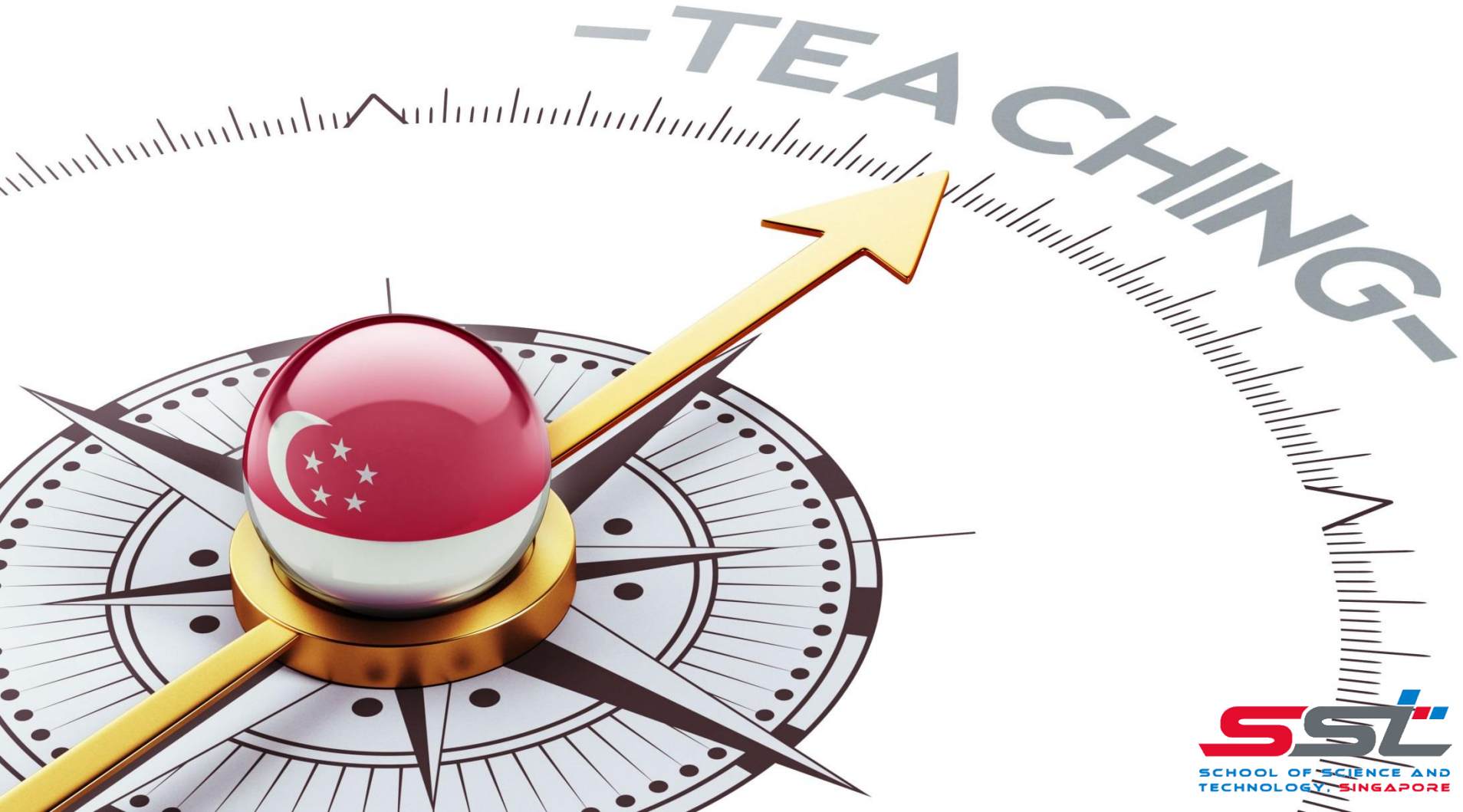
- What direction should teaching a learning take in the future?



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‘Abundance’ mentality that recognises multiple pathways to success needed, says Education Minister

“While changes in the economy have created jobs requiring specific skills and multiplied pathways, our thinking about education and pathways have not kept up with these changes,” [Mr. Heng said].

“One way the Education Ministry has tried to change such thinking is through the *Applied Learning Programme* and Learning for Life Programme, and to create opportunities in every school”.

“Parents are beginning to see how each school can offer something interesting and special,” [Mr. Heng said].

- Laura Philomin, Tuition culture has to go, say MPs, *Today*, Saturday 7th March 2015, page 9, MediaCorp Press Ltd.

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Essential Question:

How do we engage, motivate and prepare the students of today…

…to become the scientists and engineers of tomorrow?

- How should we teach?
- How should they learn?

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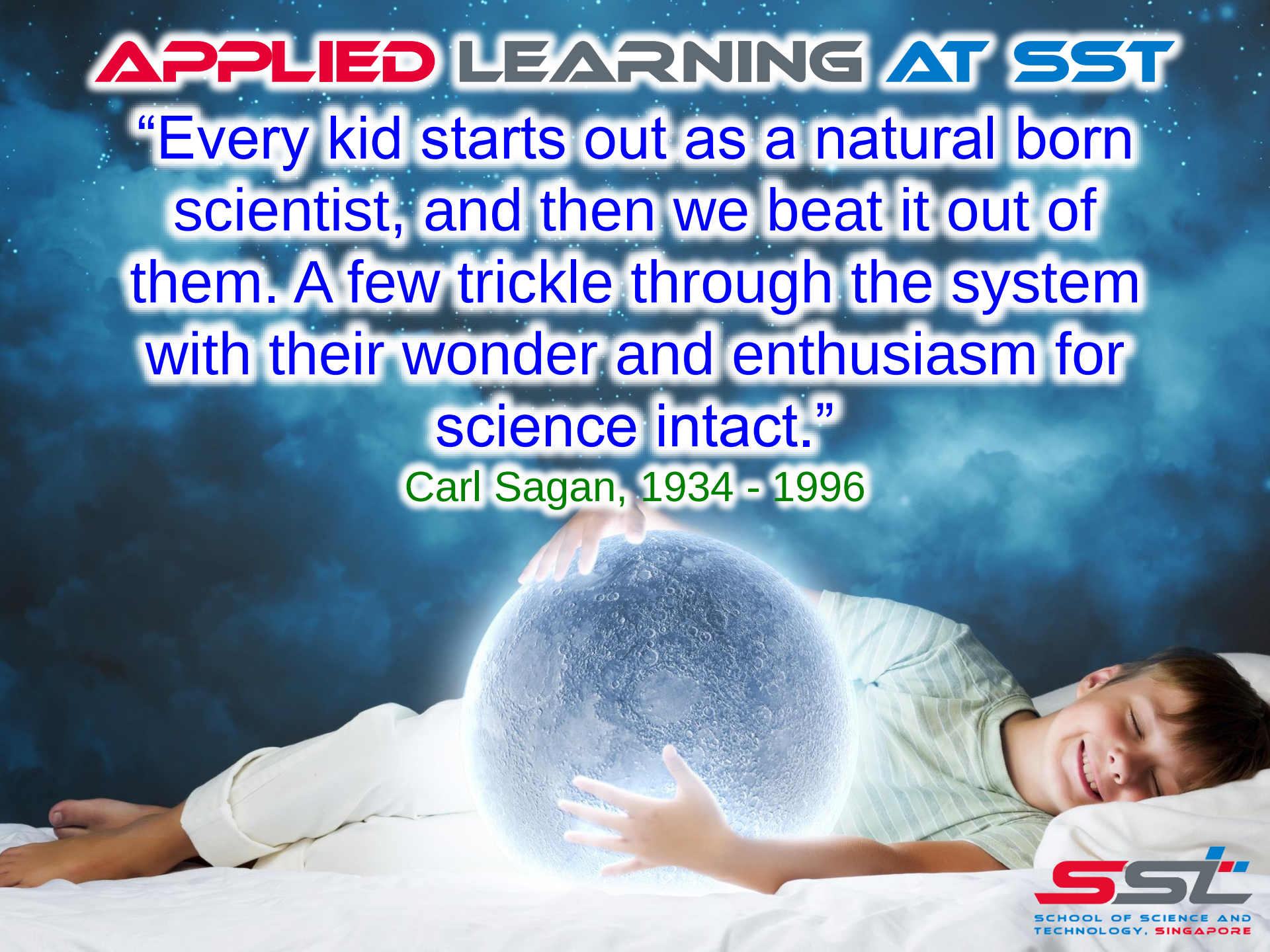
"Every kid starts out as a natural born scientist, and then we beat it out of them. A few trickle through the system with their wonder and enthusiasm for science intact."

Carl Sagan, 1934 - 1996



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Video = 10.8 seconds

- How did you learn to ride a bicycle?

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How did you learn to ride a bicycle?

- Read a book about how to ride a bike?

- Attend a lecture about how to ride a bike?

- Watch a video about how to ride a bike?

- Take a multiple-choice test about how to ride a bike?

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- Or did you learn to ride a bicycle like this?

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- Or did you learn to ride a bicycle like this?

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- Or did you learn to ride a bicycle like this?

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Video = 13.5 seconds

"Science" is a verb.

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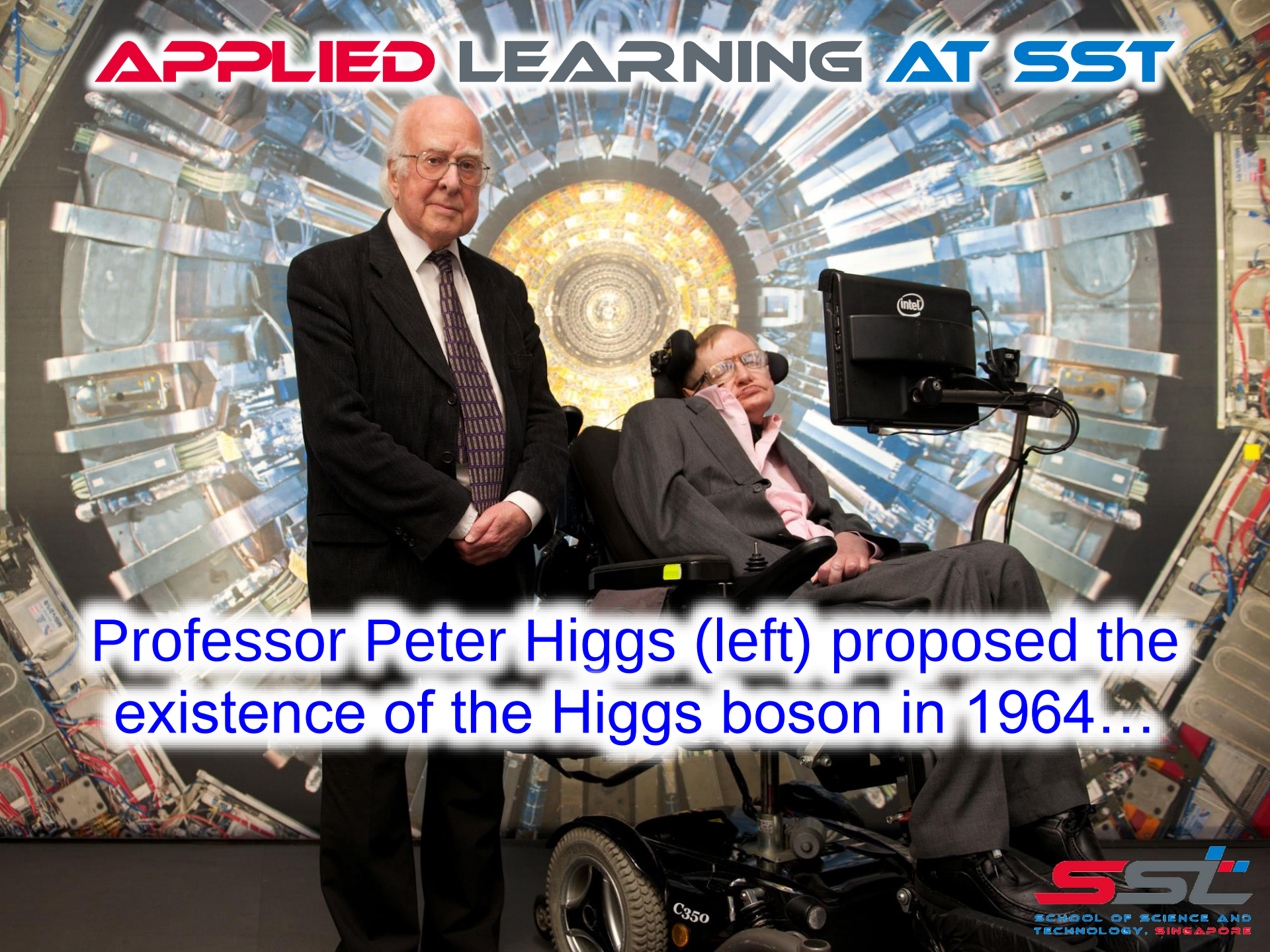

Professor Peter Higgs (left) proposed the existence of the Higgs boson in 1964…

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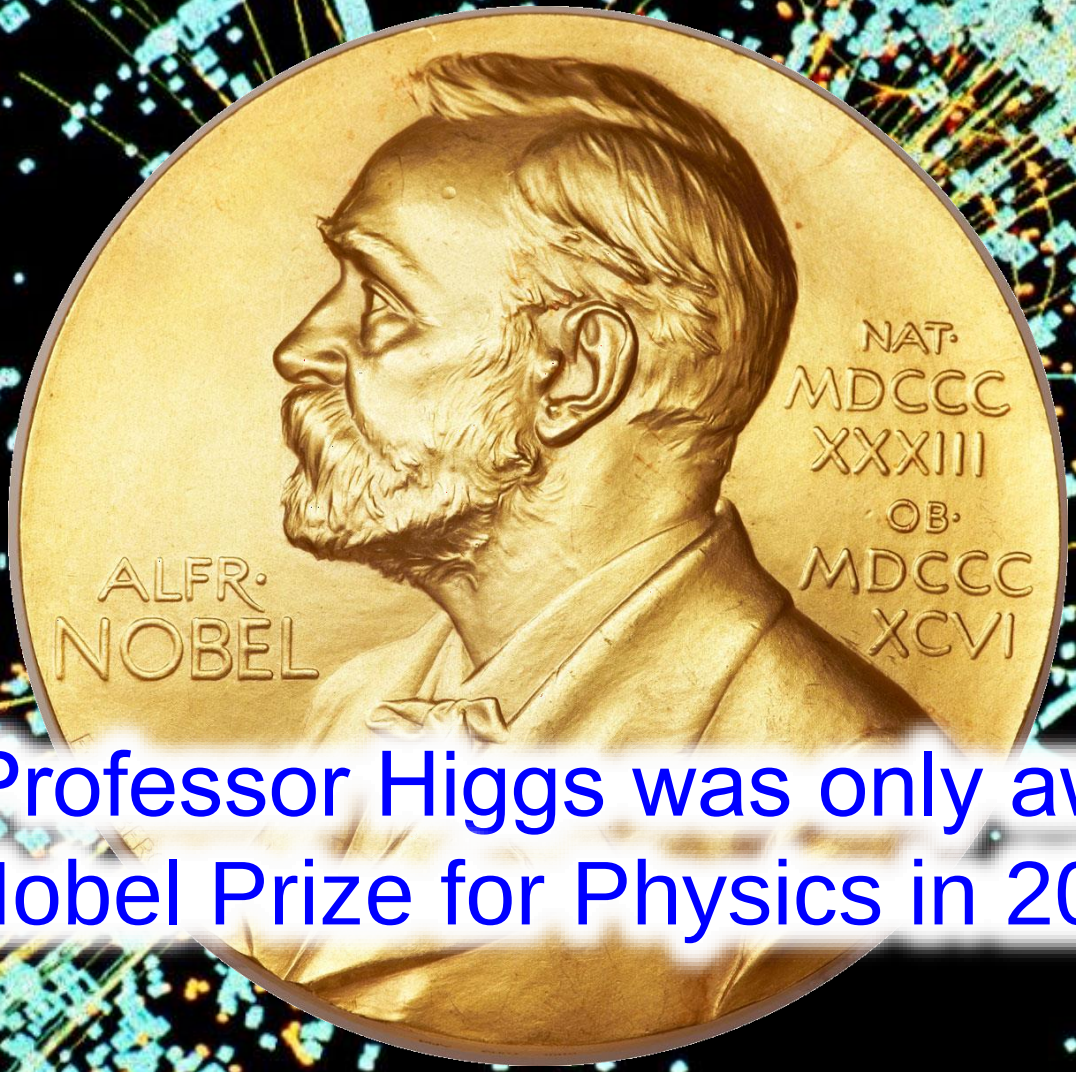

...but Professor Higgs was only awarded the Nobel Prize for Physics in 2013...

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...because the Higgs boson was only detected by the Compact Muon Solenoid at CERN on 4th July 2012.
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The Applied Learning approach guides the SST teaching and learning process so that the curriculum is delivered within a relevant real-life context to ensure that learning experiences are coherent, challenging and aimed at developing the full range of a student's capabilities and talents.

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APPLIED LEARNING IN A NUTSHELL

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- Applied learning is the application of learning.
- Students demonstrate understanding by transferring their knowledge to solve novel problems framed in a real world context.
- Students use critical and creative thinking skills while they collaborate on solving authentic problems.
- Guiding students to "think like a disciplinarian" (think like a chemist).

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APPLIED LEARNING
LESSON PLANNING

- What do I want my students to understand?
- Why is it important for them to understand this?
- What authentic problems can they solve with the cognitive skills that they have learnt?
- What authentic problems can they solve with the procedural skills that they have learnt?
- How will they demonstrate their understanding (beyond a grade on a pen-and-paper test)?

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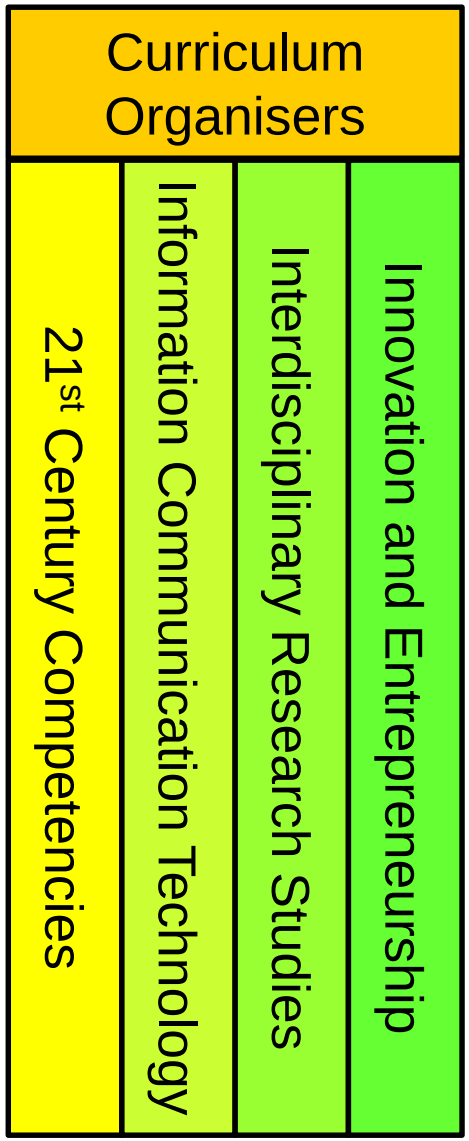
APPLIED LEARNING FRAMEWORK

The Six Facets of



Applied Learning

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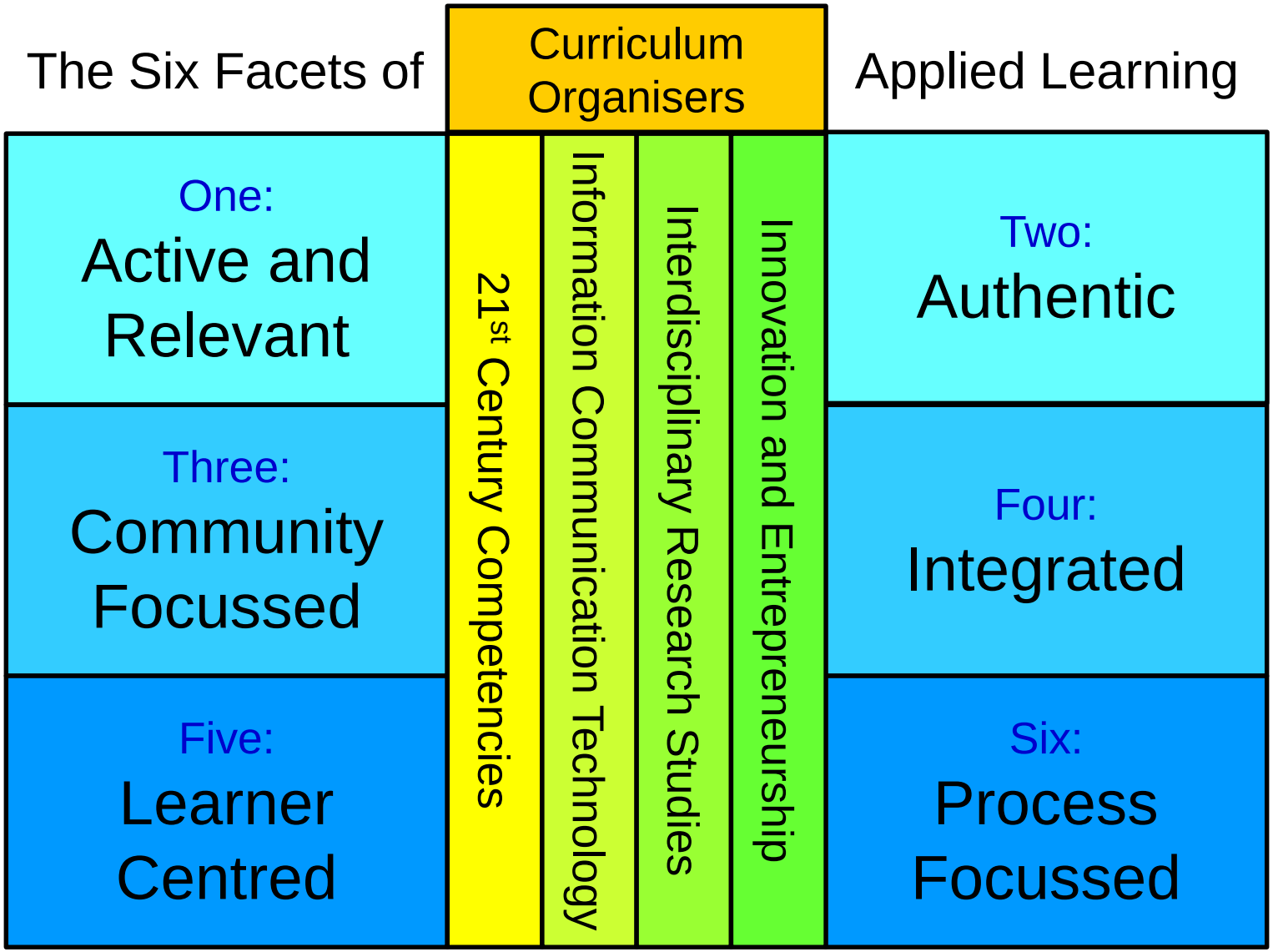
APPLIED LEARNING FRAMEWORK



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ACTIVE AND RELEVANT

- Engaging the learner as co-constructor of knowledge and meaning.
- Providing challenge through rigorous disciplinary content.
- Learning by doing and experiencing.

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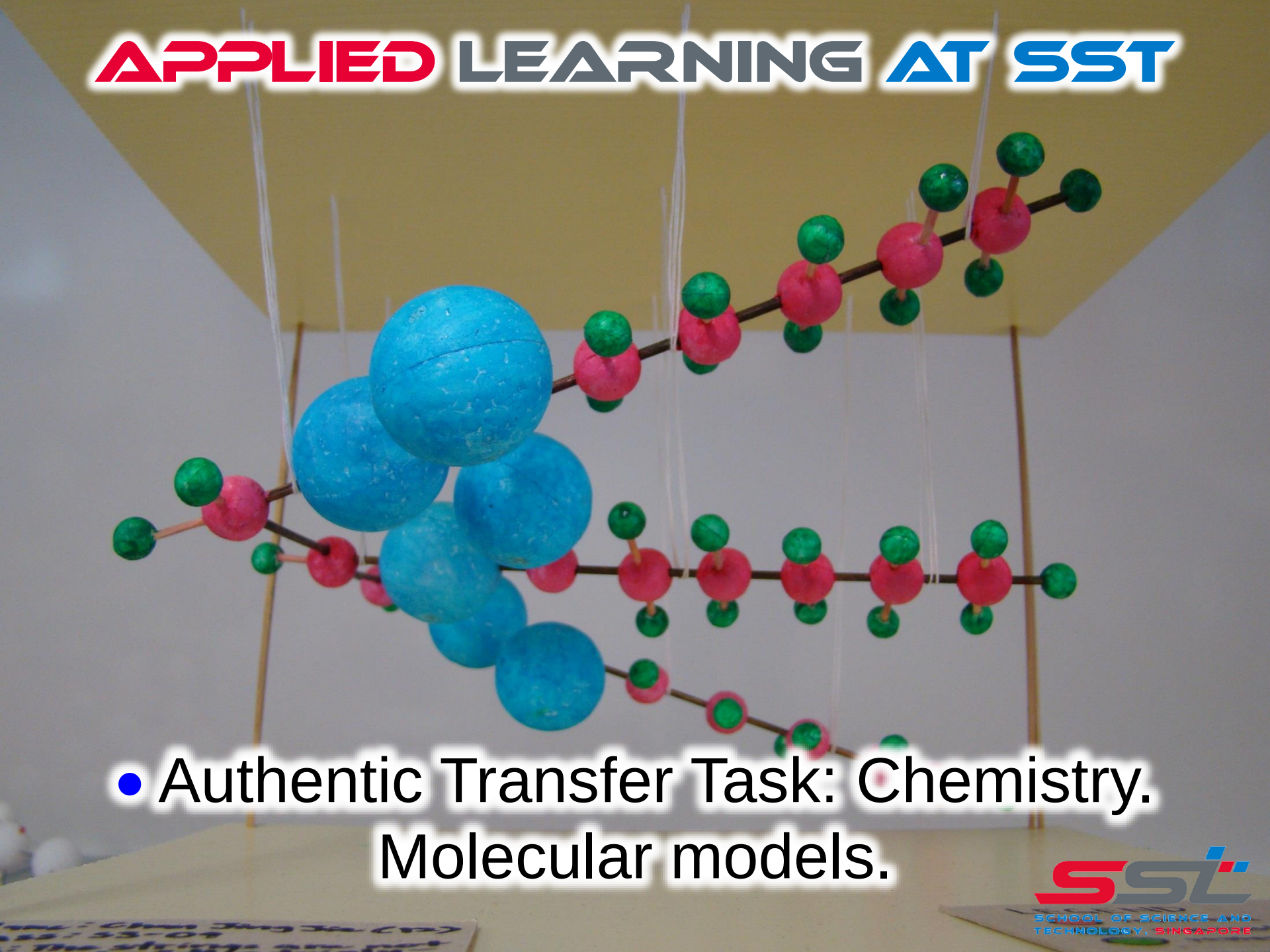

- Authentic Transfer Task: Chemistry. Molecular models.

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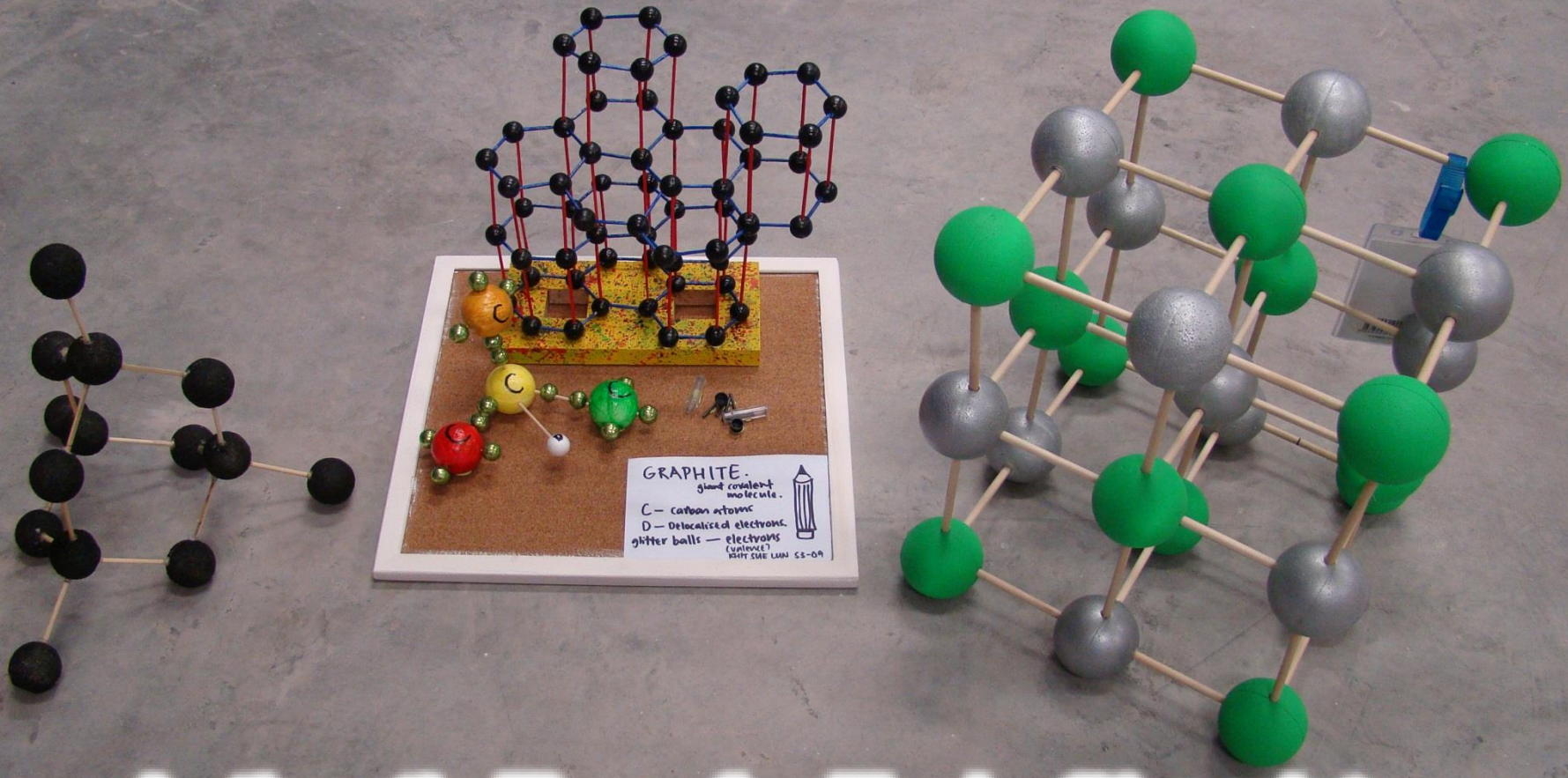

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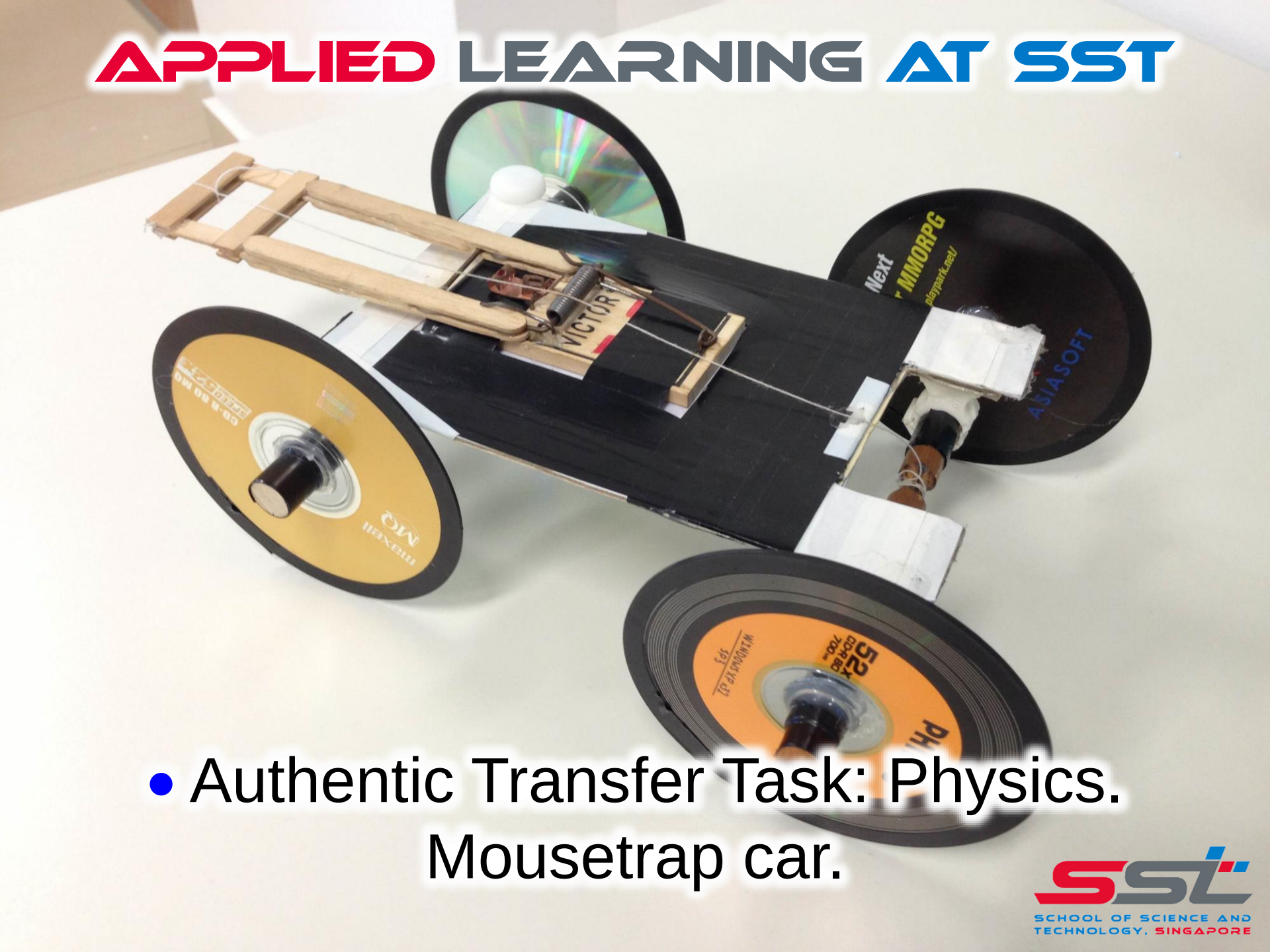

- Authentic Transfer Task: Physics.
  Mousetrap car.

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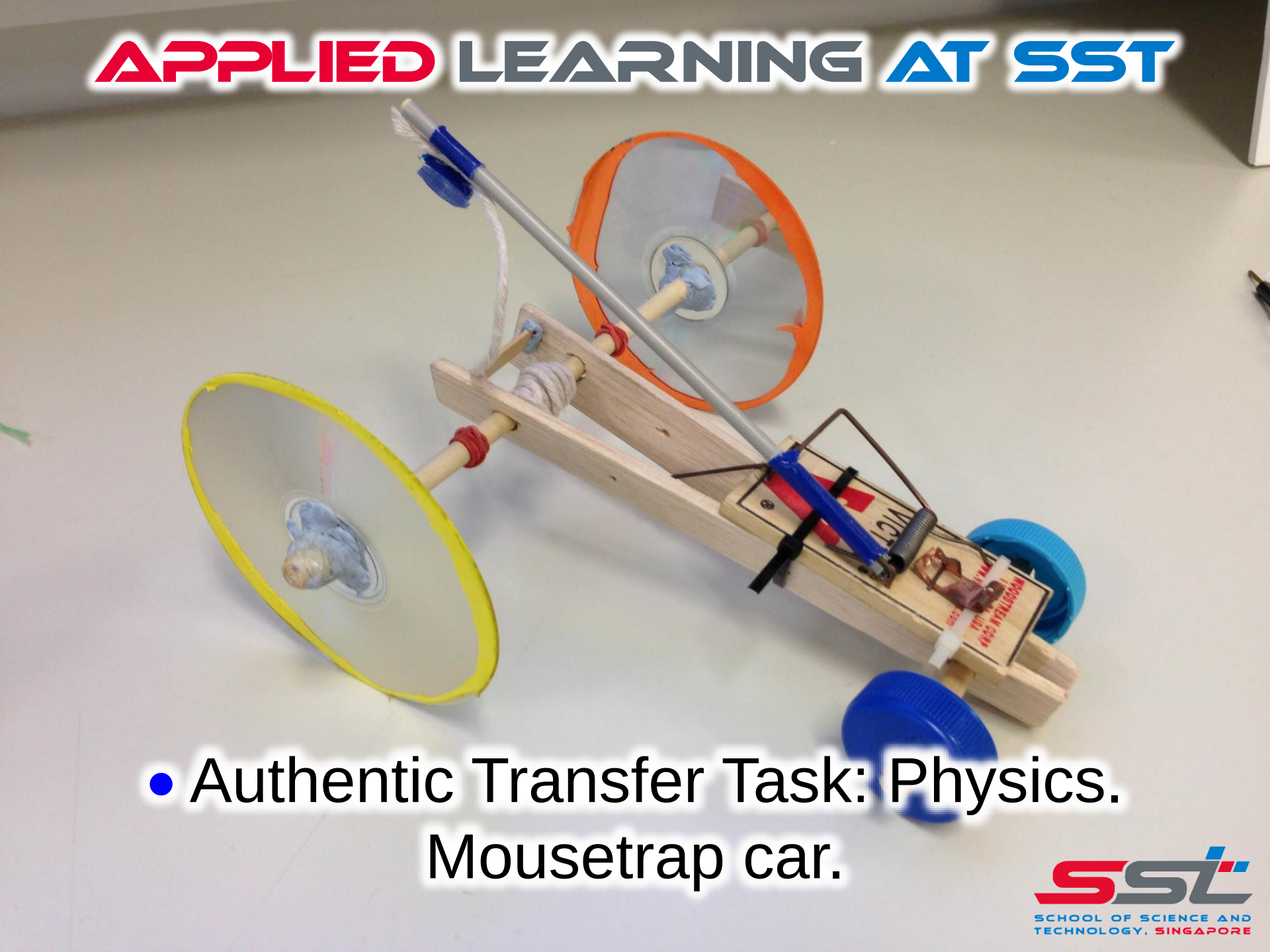

- Authentic Transfer Task: Physics. Mousetrap car.

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- Authentic Transfer Task: Biology.

- Singapore produced enough food waste last year to fill *600 Olympic size swimming pools*.

- In the recent years, there are many enthusiasts who promote recycling of kitchen waste without affecting the environment. One of the common terms is "*Garbage Enzymes*".

- As ambassadors for the environment, the students have been tasked to research on how "*Garbage Enzymes*" work, and educate their peers on their findings.

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AUTHENTIC

- Contextualising learning with tasks and resources drawn from, and applicable to, the real world.
- Developing multi-modal ways of learning.
- Learning synchronously and asynchronously.

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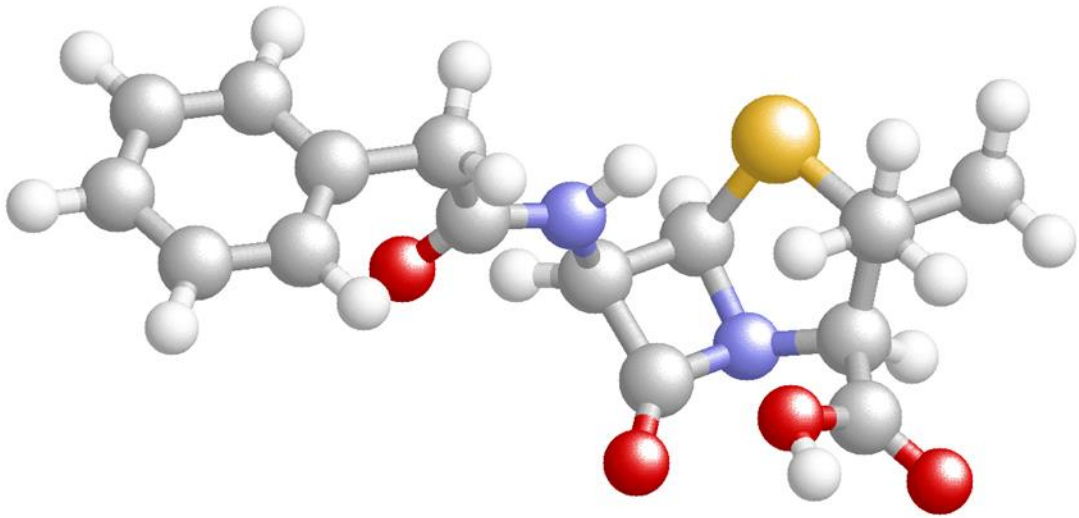

Penicillin

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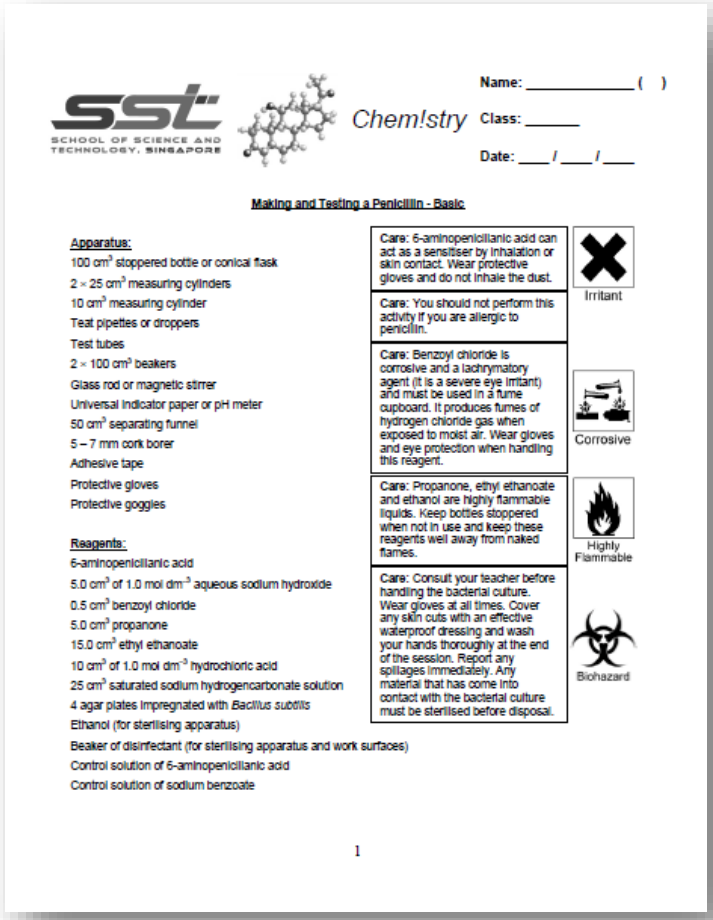
- Students study the history of antibiotics and then go on to make an test a semi-synthetic penicillin.



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Chem!stry

Name: _____ ( )

Class: _____

Date: ___ / ___ / ___

Making and Testing a Penicillin - Basic

Apparatus:

100 cm^3 stoppered bottle or conical flask
2 × 25 cm^3 measuring cylinders
10 cm^3 measuring cylinder
Teat pipettes or droppers
Test tubes
2 × 100 cm^3 beakers
Glass rod or magnetic stirrer
Universal indicator paper or pH meter
50 cm^3 separating funnel
5 – 7 mm cork borer
Adhesive tape
Protective gloves
Protective goggles

Reagents:

6-aminopenicillanic acid
5.0 cm^3 of 1.0 mol dm^{-3} aqueous sodium hydroxide
0.5 cm^3 benzoyl chloride
5.0 cm^3 propanone
15.0 cm^3 ethyl ethanoate
10 cm^3 of 1.0 mol dm^{-3} hydrochloric acid
25 cm^3 saturated sodium hydrogencarbonate solution
4 agar plates impregnated with *Bacillus subtilis*
Ethanol (for sterilising apparatus)
Beaker of disinfectant (for sterilising apparatus and work surfaces)
Control solution of 6-aminopenicillanic acid
Control solution of sodium benzoate

Care: 6-aminopenicillanic acid can act as a sensitiser by inhalation or skin contact. Wear protective gloves and do not inhale the dust.

Irritant

Care: You should not perform this activity if you are allergic to penicillin.

Care: Benzoyl chloride is corrosive and a lachrymatory agent (it is a severe eye irritant) and must be used in a fume cupboard. It produces fumes of hydrogen chloride gas when exposed to moist air. Wear gloves and eye protection when handling this reagent.

Corrosive

Care: Propanone, ethyl ethanoate and ethanol are highly flammable liquids. Keep bottles stoppered when not in use and keep these reagents well away from naked flames.

Highly Flammable

Care: Consult your teacher before handling the bacterial culture. Wear gloves at all times. Cover any skin cuts with an effective waterproof dressing and wash your hands thoroughly at the end of the session. Report any spillages immediately. Any material that has come into contact with the bacterial culture must be sterilised before disposal.

Biohazard

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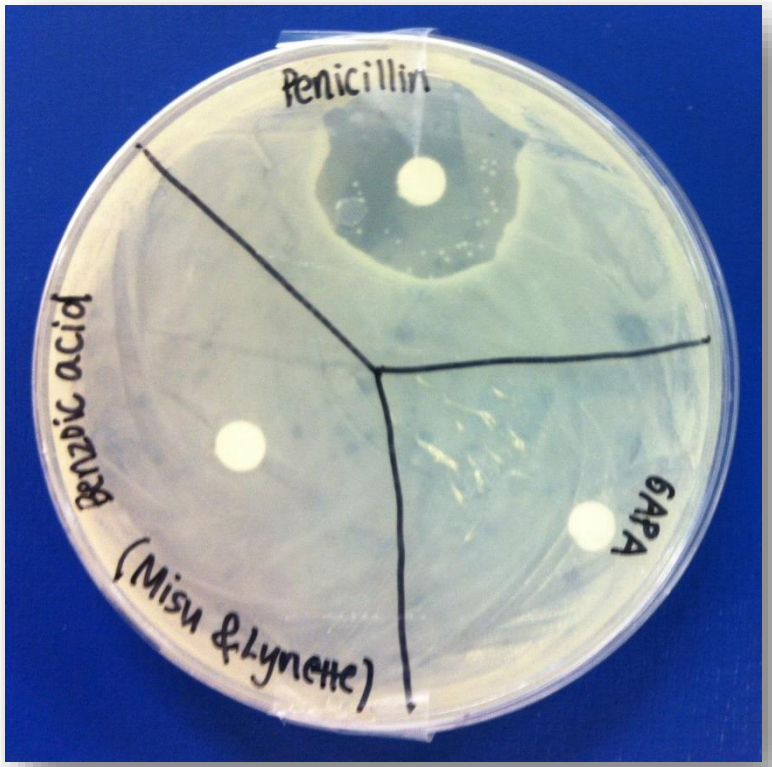

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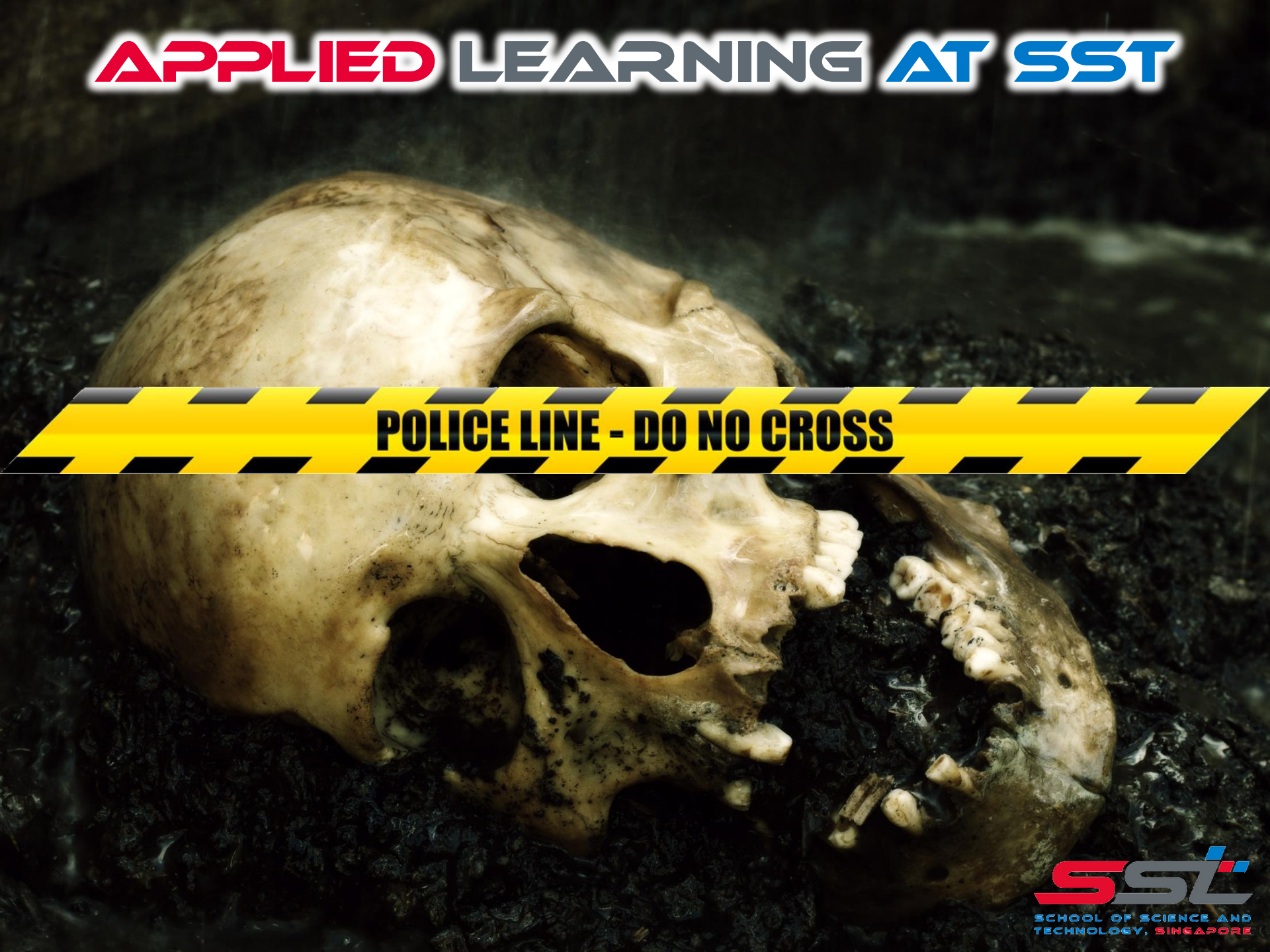

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Crime scene investigation for qualitative analysis.

- Students analyse a compound found at a crime scene to identify which anions and cations it contains.
- Students then submit a forensic science report to the police.

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- The body of a young man has been found on Marina Bay Golf Course.
- The cause of death is drowning.
- You are provided with a sample of water from the victim's lungs.
- You are also provided with water samples from Marina Bay, Geylang River (near a construction site) and the sea.
- By qualitative analysis, identify the anions and cations in all four samples of water and hence determine where the victim drowned.

Map data © Google 2015, © Urban Redevelopment Authority Imagery 2015.

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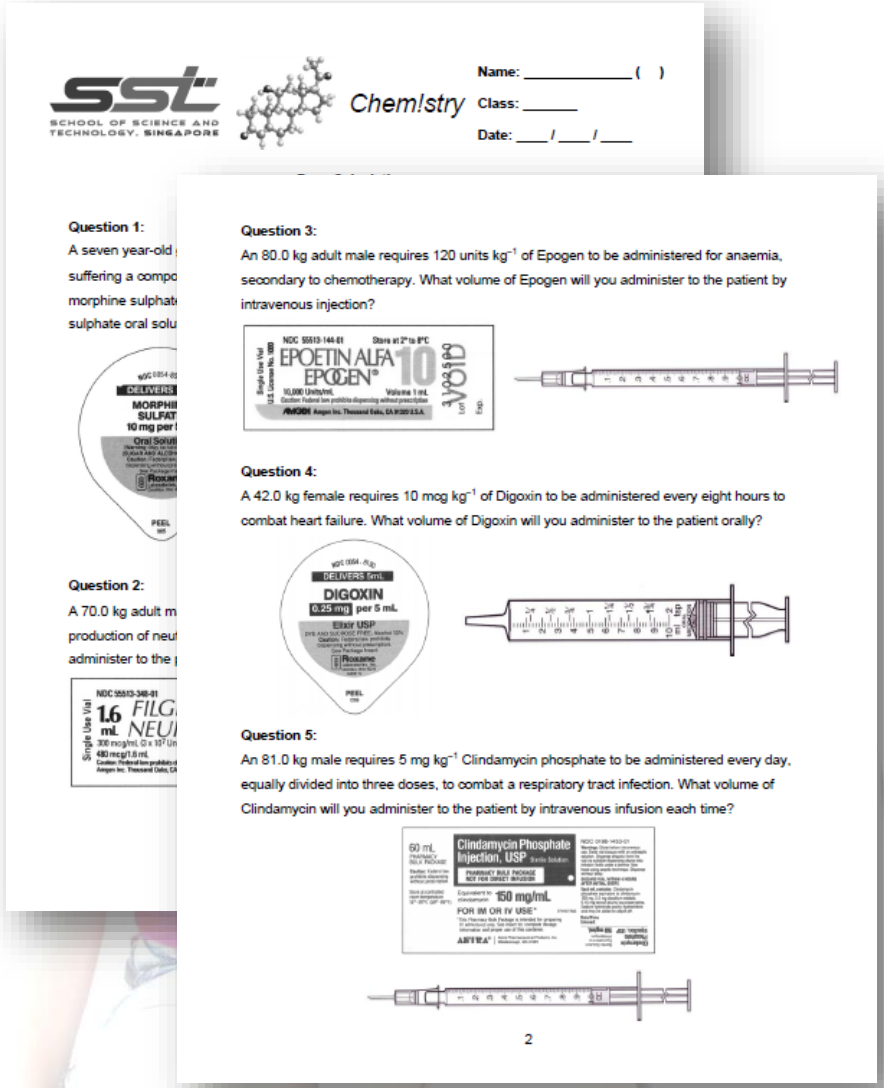

- Students apply their knowledge of mole calculations to drug calculations and determining the concentration of electrolytes in a patients' blood.

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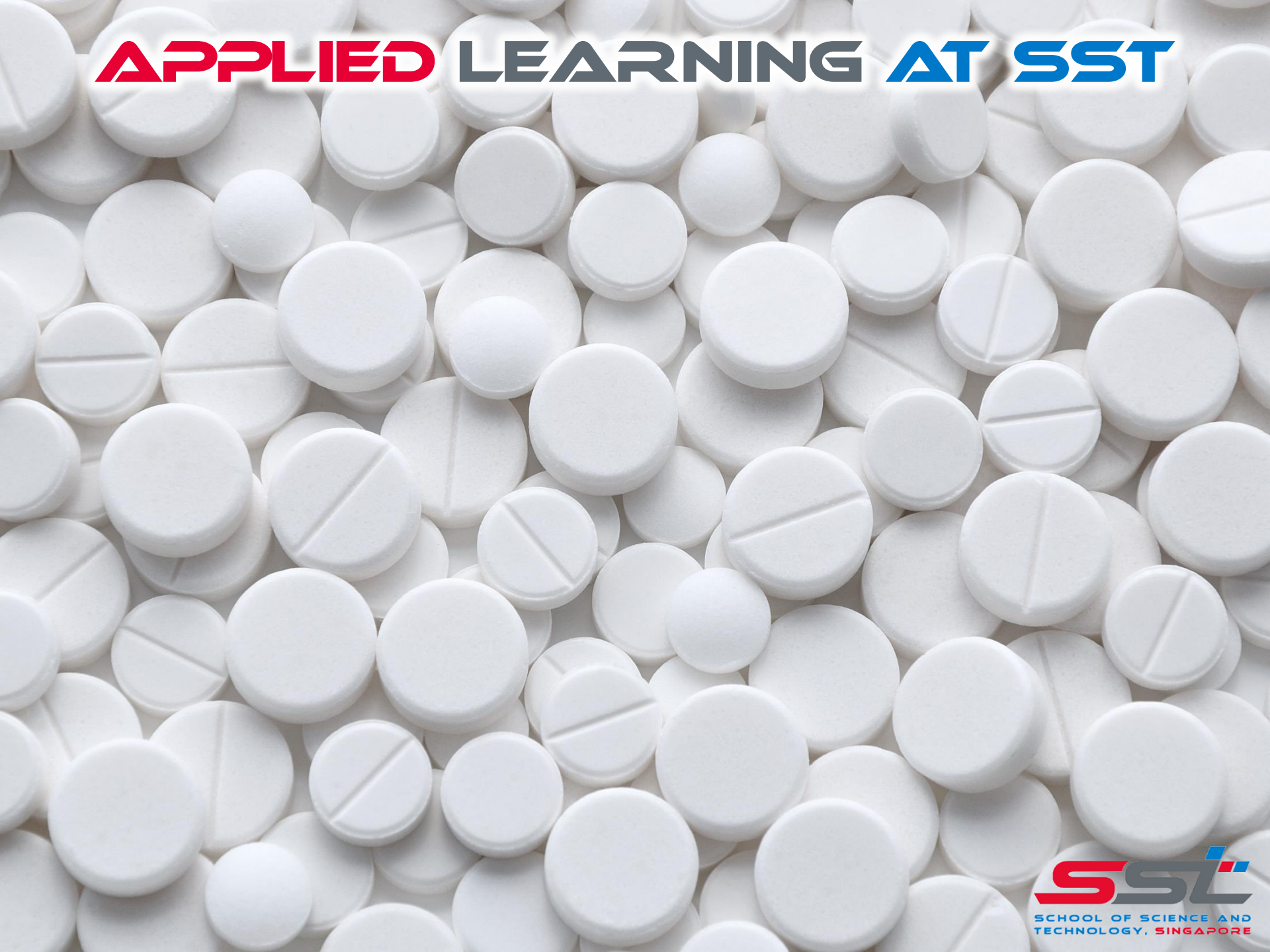

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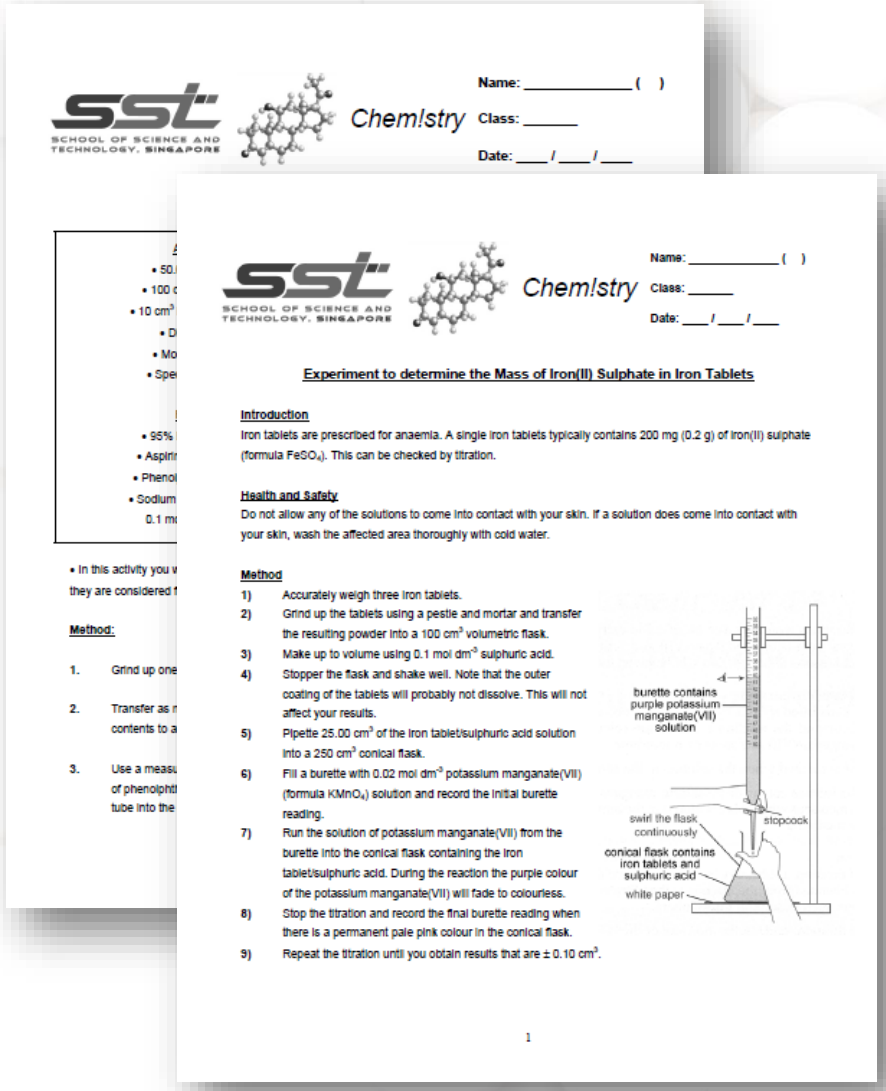

- Students determine the amount of aspirin in aspirin tablets and the amount of iron in iron(II) sulfate tablets by titration.

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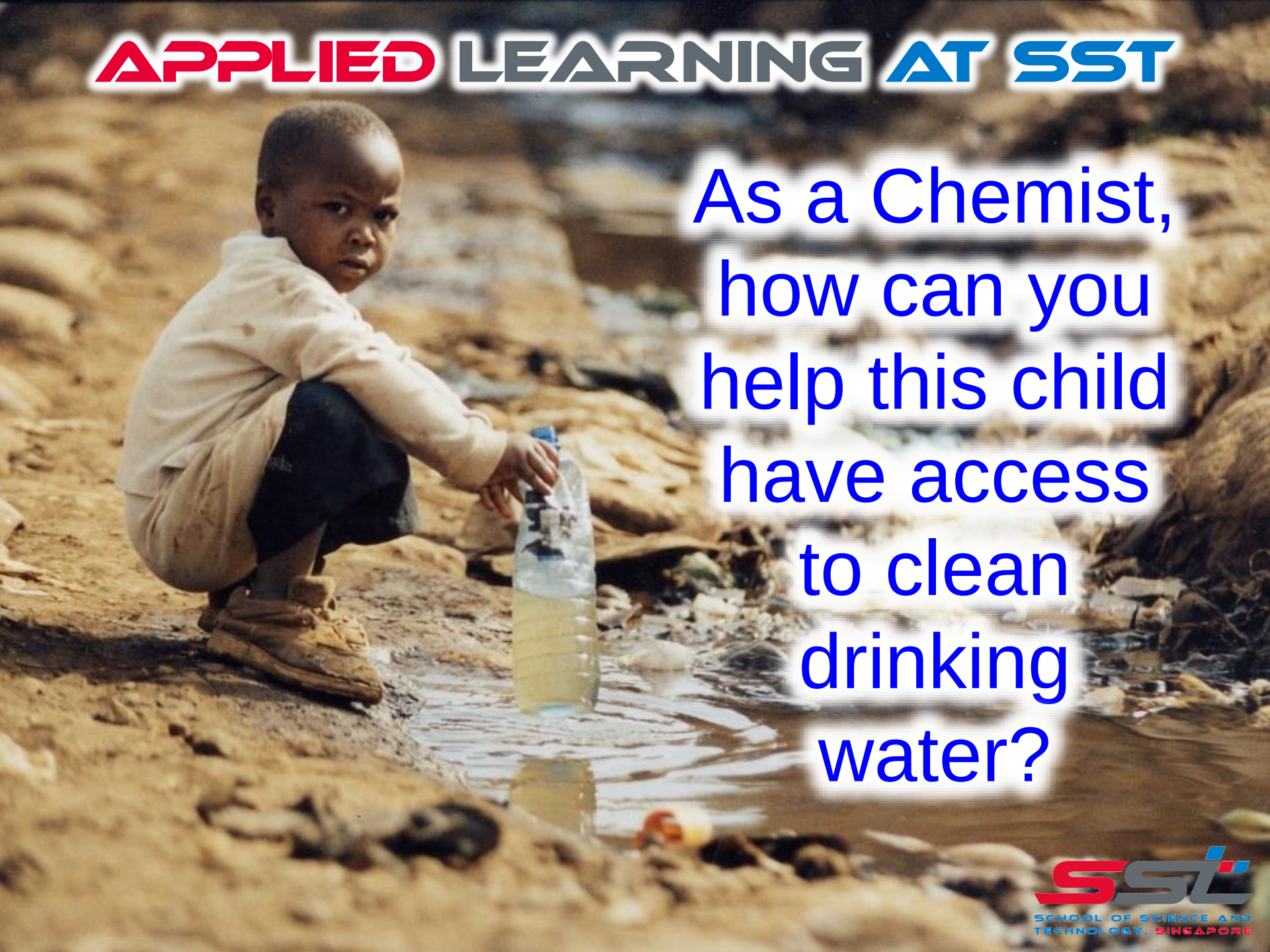

As a Chemist, how can you help this child have access to clean drinking water?

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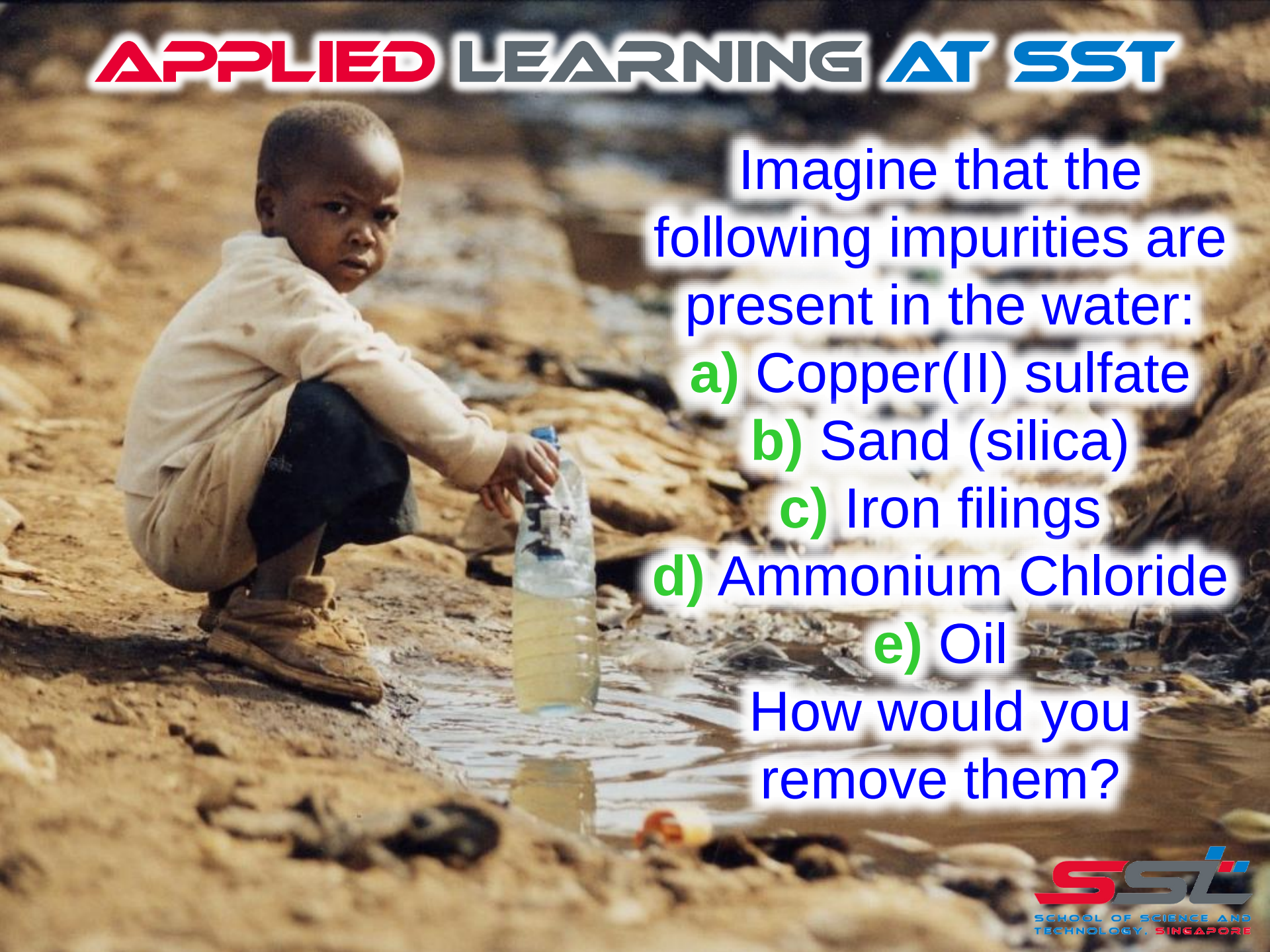

Imagine that the following impurities are present in the water:

a) Copper(II) sulfate

b) Sand (silica)

c) Iron filings

d) Ammonium Chloride

e) Oil

How would you remove them?

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COMMUNITY FOCUSED

- Building a borderless community of learners.
- Inculcating respect for diverse ideas.
- Developing stewardship of issues in the community and world at large.

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APPLIED LEARNING AT SST

Atmosphere – Community Focus

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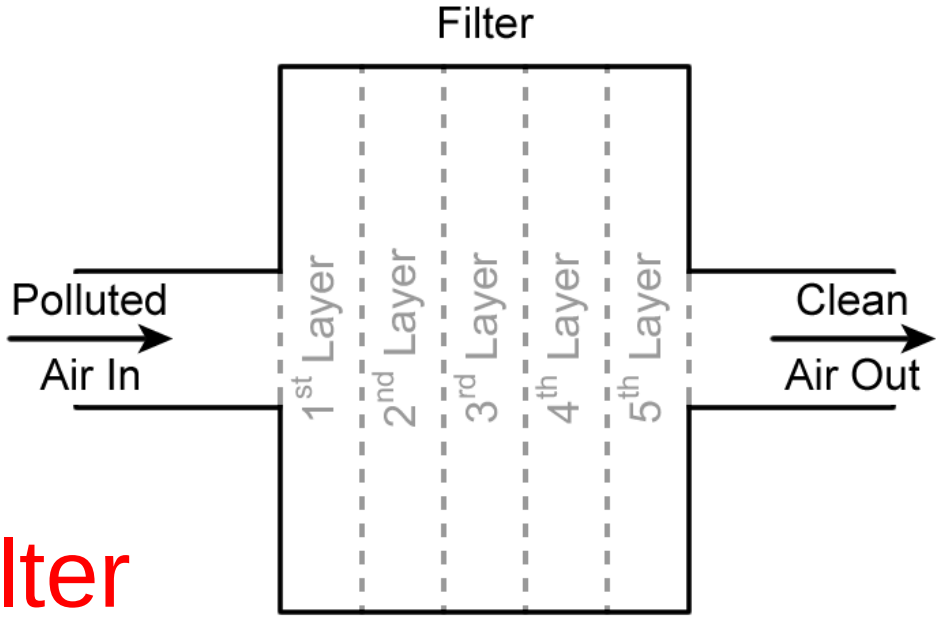
Atmosphere – Community Focus

- Which atmospheric pollutants are contained within the yearly *haze* that Singapore experiences due to “slash-and-burn” cultivation in neighbouring countries?

- To what extent are paper facemasks effective at removing atmospheric pollutants contained within the *haze*?

Atmosphere – Community Focus



- Students design a gas mask based upon what they have learnt about atmospheric pollution.

Separation and Purification

- **Essential Question:** Why it is important for these different substances to be free from contamination?

Separation and Purification

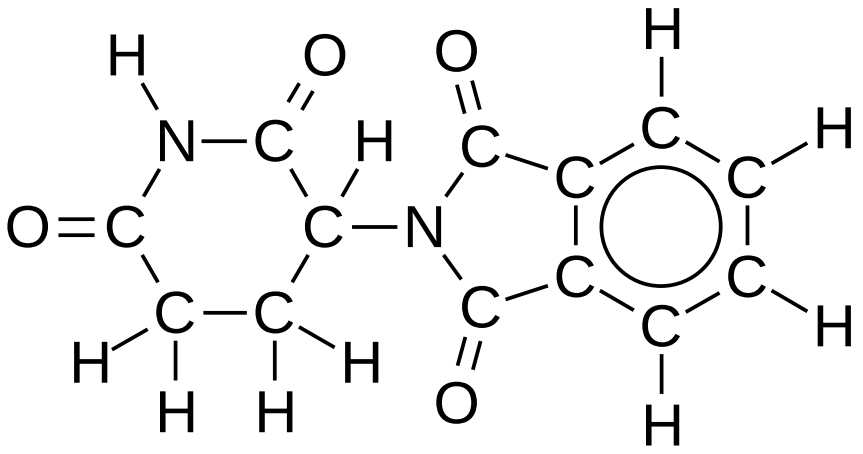
To illustrate why it is important for food and drugs to be free from contamination, use your learning device to search for information on the drug *thalidomide*.

- What condition was thalidomide used to treat?

- What serious health problems arose from the use of thalidomide? Why?

- During the manufacture of the drug, what could have been done to avoid these serious health problems?

Separation and Purification



Thalidomide was used by pregnant women in the 1950s and 1960s to combat the effects of morning sickness. The thalidomide molecule exists in two different forms called *isomers*. One of these isomers was successful in reducing the effects of morning sickness, but the other isomer was found to be *teratogenic* (causes deformities in a developing foetus). Because the two isomers *were not separated* from each other, many of the women who took the drug thalidomide gave birth to children with serious physical deformities.

APPLIED LEARNING AT SST

INTEGRATED

- Intra and inter-disciplinary learning and problem solving.
- Teaching for enduring understanding and transference.
- Strengthening values, leadership and citizenship.

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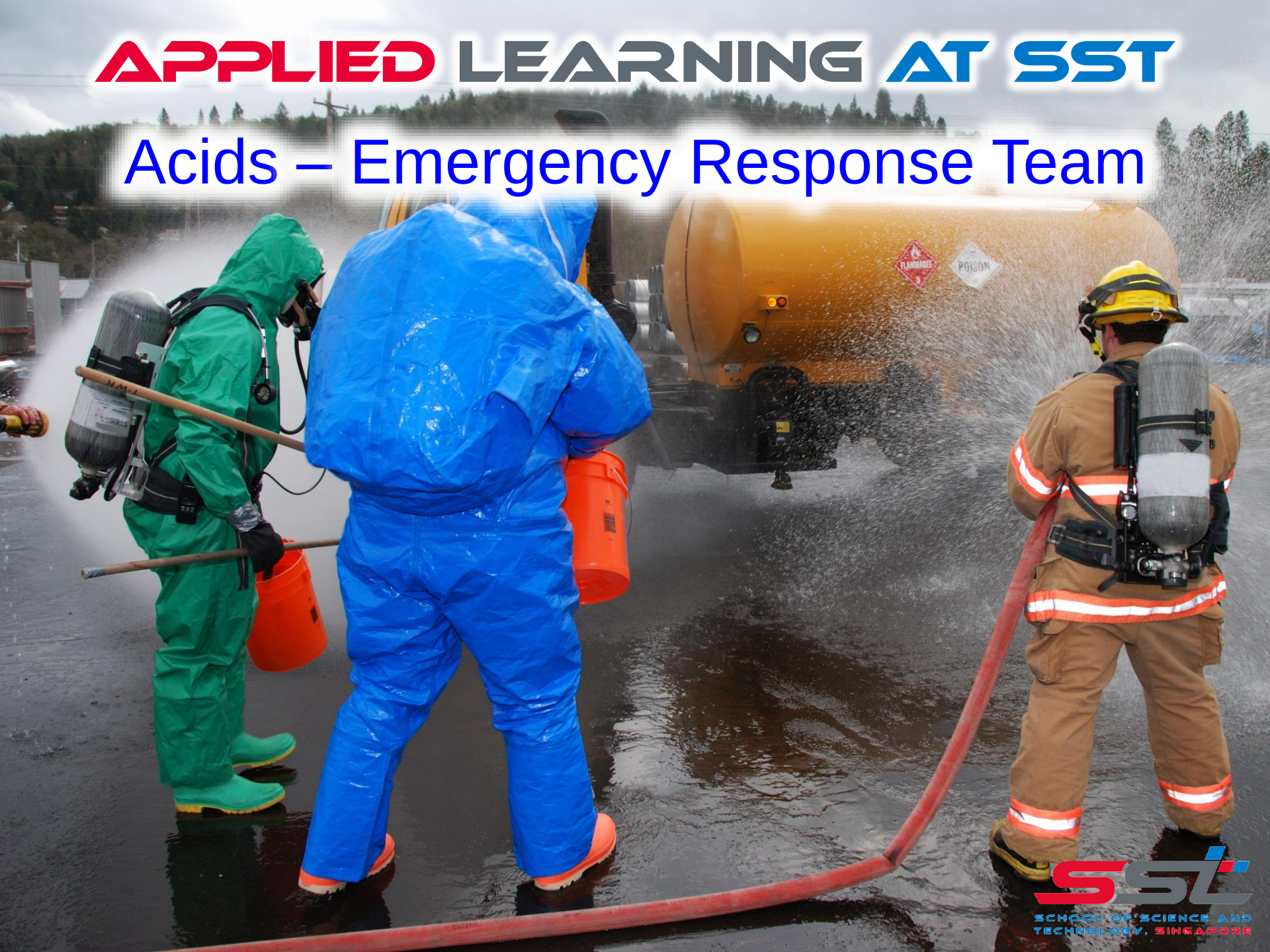
Acids – Emergency Response Team



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Acids – Emergency Response Team

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Acids – Emergency Response Team

- A road tanker carrying 30 000 dm^3 of an unknown solution has been involved in an accident with another vehicle.

- The incident has taken place on a road directly adjacent to a large reservoir.

- The drivers of both vehicles have been stabilised at the scene and transported to hospital for further treatment.

- The accident has resulted in the road tanker overturning. It is currently positioned very close to the edge of the reservoir, and is leaking an unknown solution from a hole in its side.

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Acids – Emergency Response Team

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Acids – Emergency Response Team

- You are a highly qualified specialist in charge of a small team of people trained to deal with the large scale spillage of chemicals.
- You arrive at the scene of the accident 10 minutes after the first police car and ambulance.

- The area has already been cordoned-off, and members of the general public are held back at a safe distance.
- You immediately notice that some of the unknown solution is leaking from the road taker into the reservoir.

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Acids – Emergency Response Team

- Your immediate task is to identify the unknown solution that is leaking from the road tanker.

- Secondly, you should identify the hazards that the unknown solution poses to your team and the environment around the road tanker.

- Thirdly, based upon what you have learned about the unknown solution, you should propose a rapid and effective way of containing and neutralising the chemical spillage.

- Finally, you should submit a detailed scientific report of your findings to the chief scientific officer: christopher_slatter@sst.edu.sg

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Acids – Emergency Response Team

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Acids – Emergency Response Team

- The meteorological office reports that a storm, bringing heavy rain, will move into your area from the South-East within the next 50 minutes.

- Consequently, you have been given a maximum of 40 minutes to complete this emergency exercise.

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LEARNER CENTRED

- Honouring student talents and interests.
- Differentiating learning experiences.
- Developing dispositions for learning while learning.

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PARENTAL
ADVISORY
EXPLICIT CONTENT

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The Chemistry of Love

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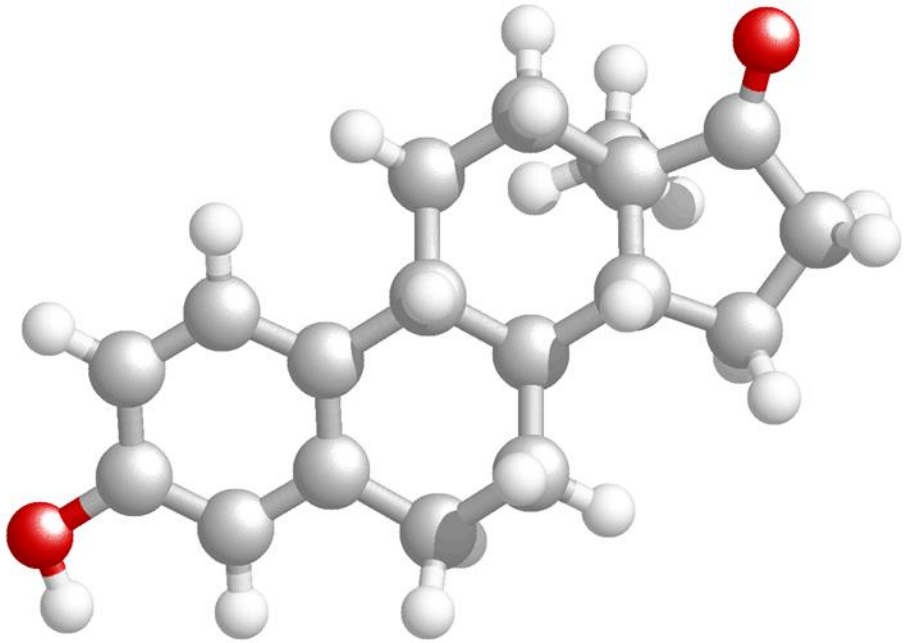

♥ *Hormones* are chemical messengers that travel throughout the body in the circulatory system.

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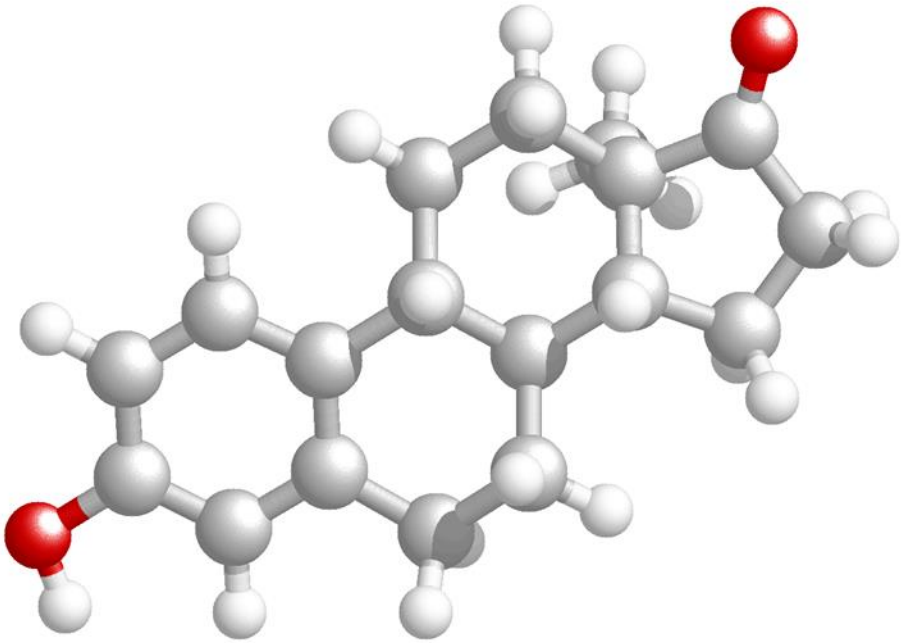

♥ Compared to signals that are sent through the body via the central nervous system, signals sent using hormones have a *slower* response time but have a *longer lasting effect*.

APPLIED LEARNING AT SST

Photographs of identical twin sisters with different oestrogen levels.

♥ Research carried out at the University of St. Andrews suggests that women with high levels of the sex hormone *oestrogen* have prettier faces. The findings make evolutionary sense because it means that men are attracted to the most fertile women. Oestrogen levels during puberty can impact on appearance by affecting bone growth and skin texture.

http://news.bbc.co.uk/go/pr/fr/-/1/hi/health/4396230.stm

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APPLIED LEARNING AT SST

Photographs of identical twin sisters with different oestrogen levels.

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APPLIED LEARNING AT SST

PROCESS FOCUSED

- Fostering higher-order-thinking through critical thinking models and creative problem solving strategies.
- Uncovering the heart of disciplines through inquiry.
- Teaching disciplines as a way of thinking and doing.

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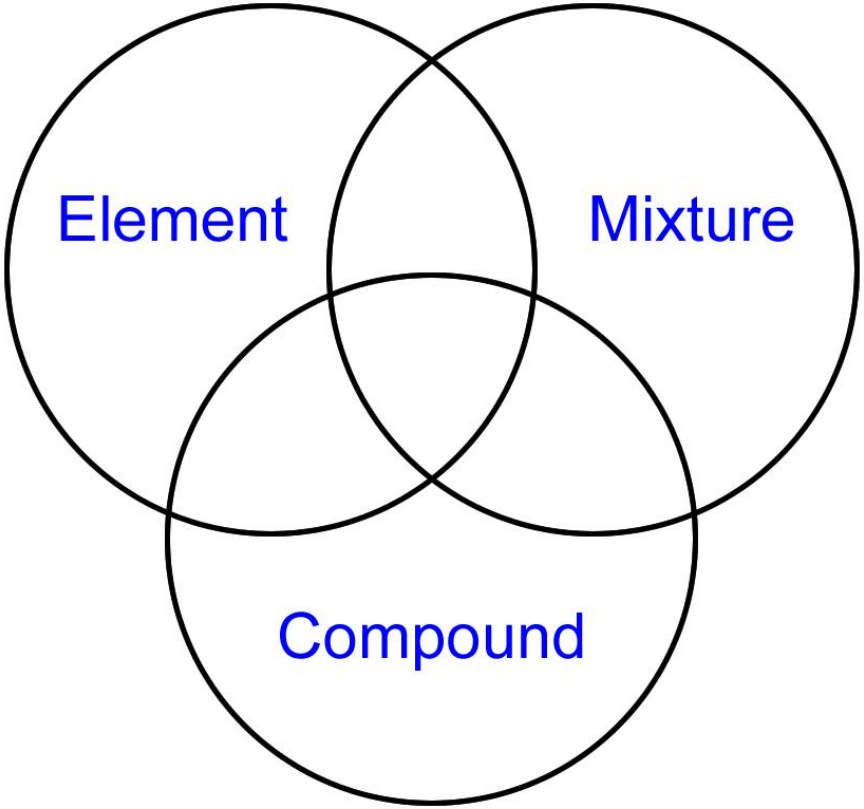
Higher Order Thinking Skills

- Roberts, J. L., & Inman, T. F. (2007). *Strategies for differentiating instruction*. Waco, Texas: Prufrock Press, Inc.

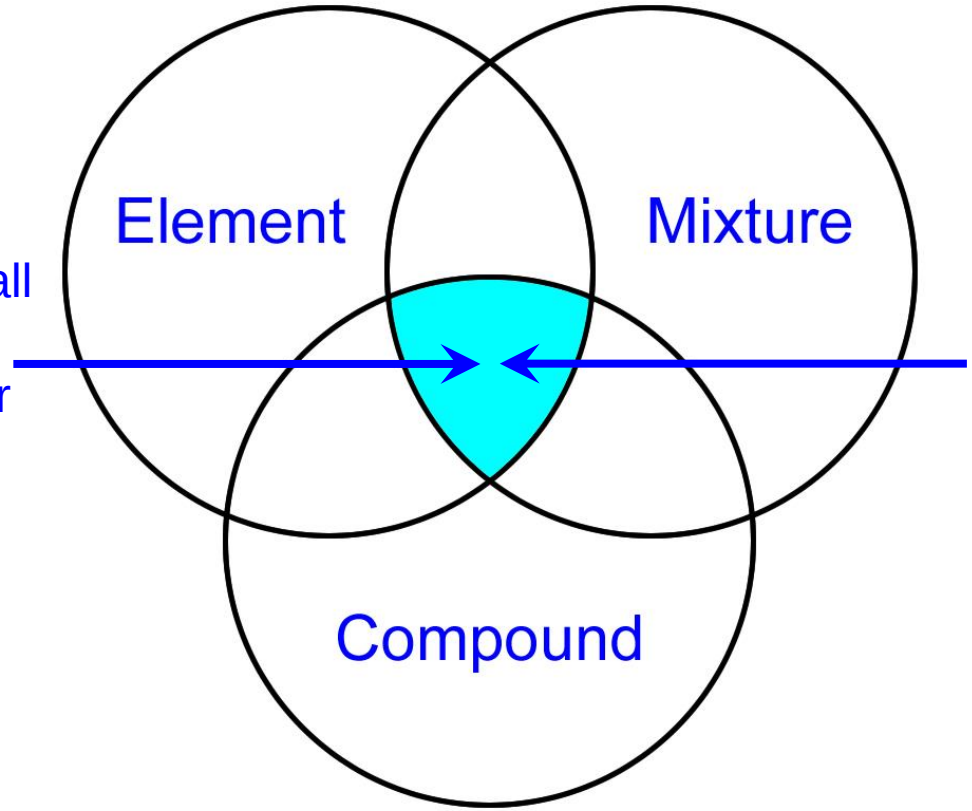


Higher Order Thinking Skills

- Roberts, J. L., & Inman, T. F. (2007). *Strategies for differentiating instruction*. Waco, Texas: Prufrock Press, Inc.

In what ways are elements, compounds and mixtures *all similar* to each other?

e.g. They are all composed of atoms, ions or molecules.

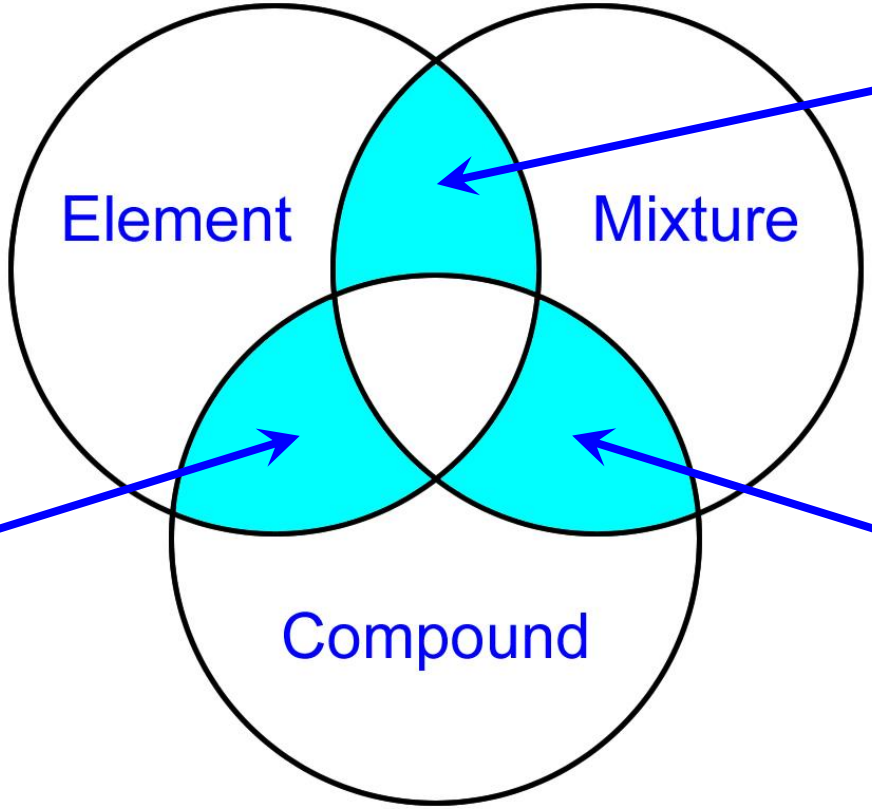


e.g. Compounds and mixtures are composed of different chemical elements which may or may not be chemically bonded together.

Higher Order Thinking Skills

- Roberts, J. L., & Inman, T. F. (2007). *Strategies for differentiating instruction*. Waco, Texas: Prufrock Press, Inc.

In what ways are the *pairs similar* to each other?



e.g. A simple mixture is composed only of only two chemical elements.

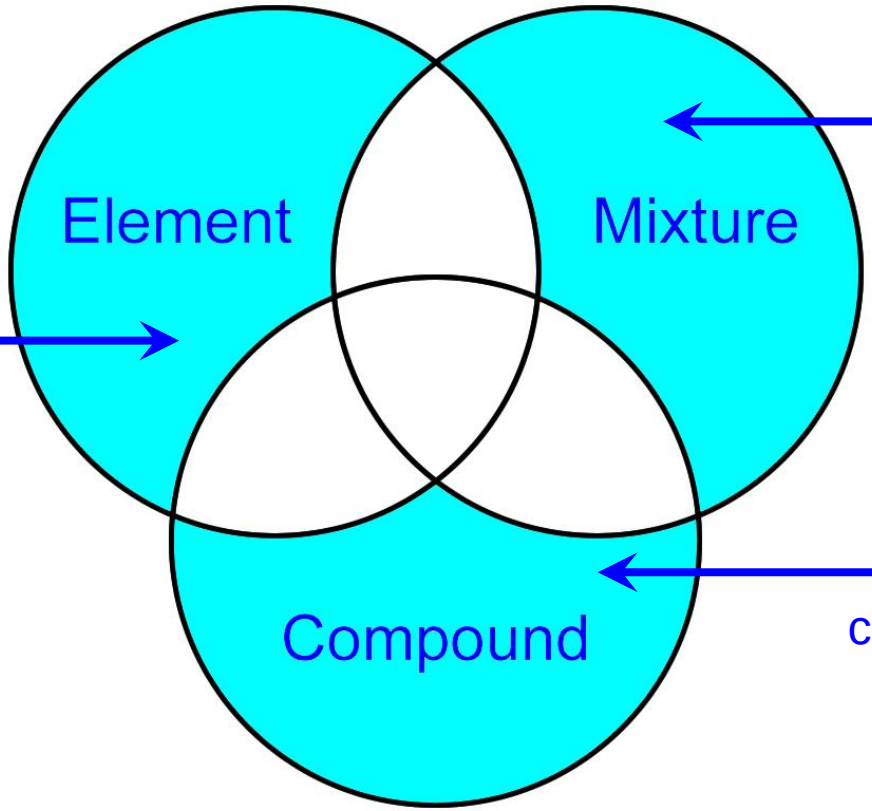
e.g. They are both pure substances.

e.g. They are both composed of more that one chemical element.

Higher Order Thinking Skills

- Roberts, J. L., & Inman, T. F. (2007). *Strategies for differentiating instruction*. Waco, Texas: Prufrock Press, Inc.

In what ways are elements, compounds and mixtures *different* from each other?



e.g. Elements are composed of only one type of atom.

e.g. The components of a mixture can be separated by a physical process.

e.g. The ratio of elements in a compound is fixed.

APPLIED LEARNING AT SST

THE MILK BOTTLE EXPERIMENT

1. Predict what will happen.

2. Observe what happens.

3. Explain what has happened.

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APPLIED LEARNING AT SST

THE MILK BOTTLE EXPERIMENT

1. Predict what will happen.

2. Observe what happens.

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APPLIED LEARNING AT SST

THE MILK BOTTLE EXPERIMENT

1. Predict what will happen.

2. Observe what happens.

3. Explain what has happened.

- Individual thinking.
- Group discussion (brainstorming and evaluation).
- PowerPoint / Keynote design.
- Virtual gallery walk.
- Teacher facilitated class discussion.

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APPLIED LEARNING AT SST

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Mystery Tubes

- Each cardboard tube has four holes, through which there is a piece of string.
- Students gently pull the pieces of string and observe what happens.
- Students suggest possible relationships between the variables.
- Students draw conclusions about what cannot be observed directly.
- The activity challenges the students to think critically.
- The activity can be used as an introduction to atomic structure.

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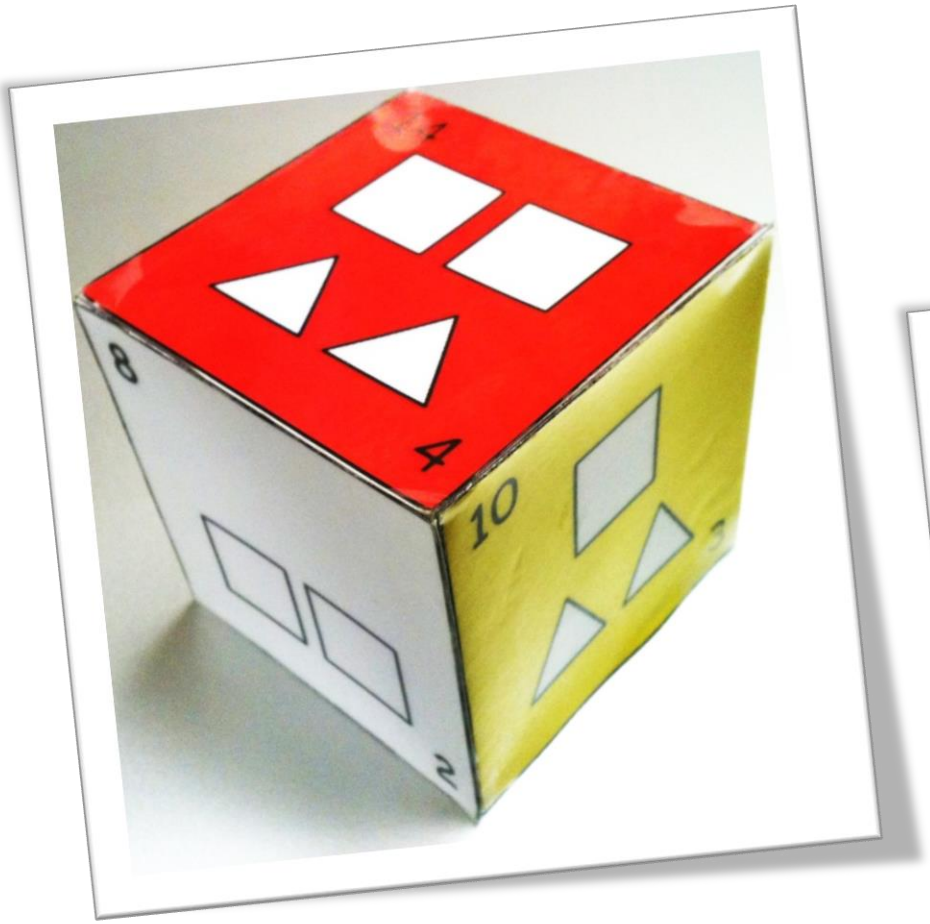
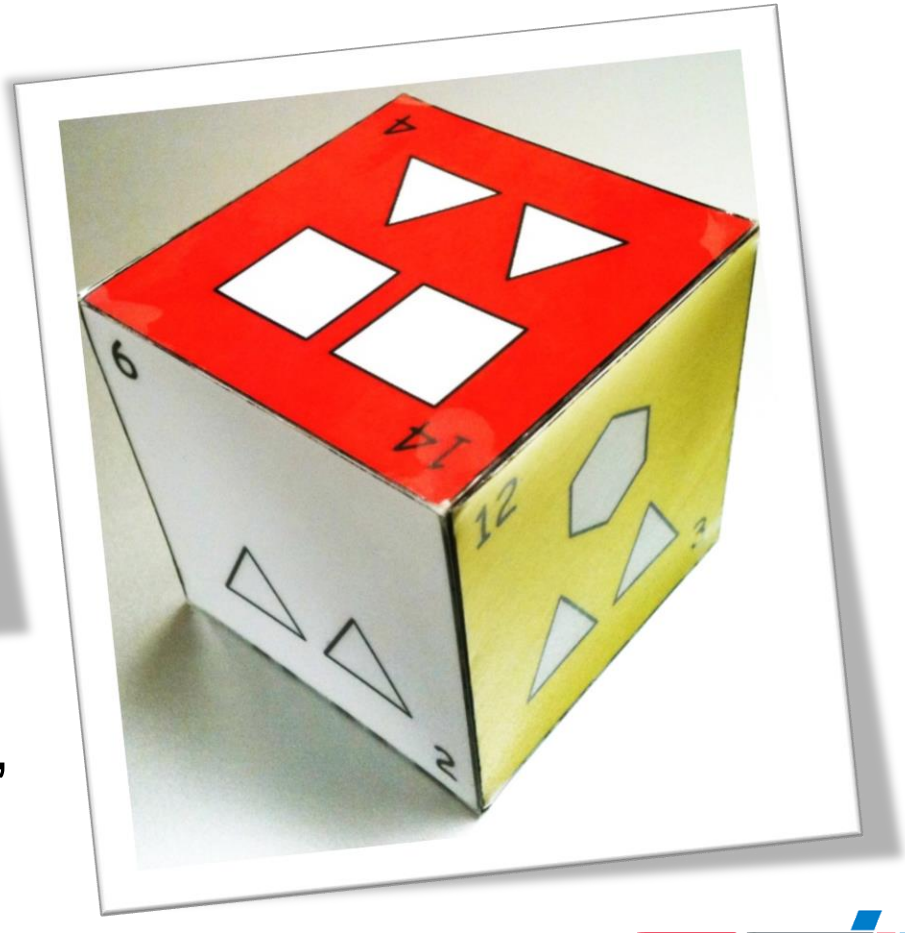
APPLIED LEARNING AT SST

Curiosity Cubes





- From the information given, deduce what the pattern on the bottom of the cube is.

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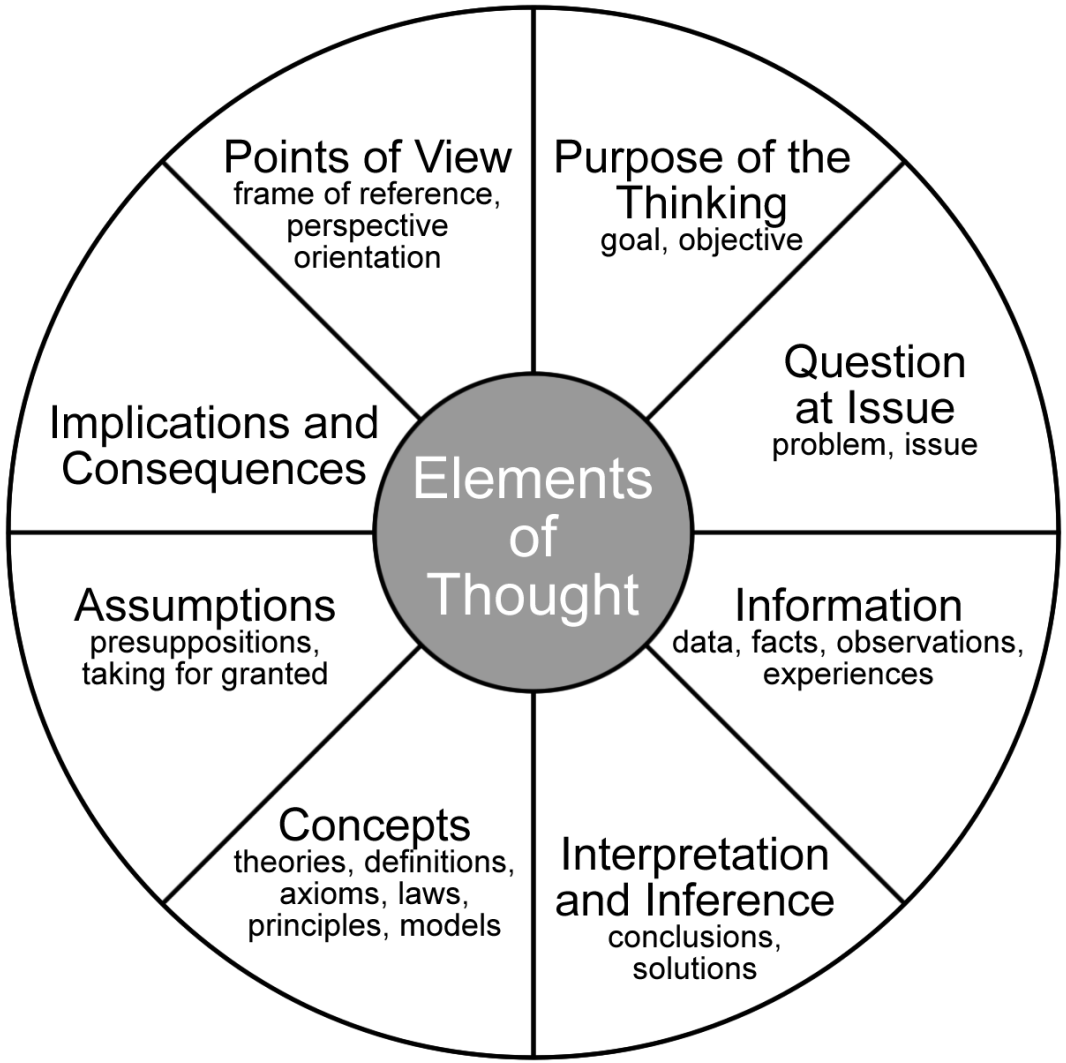
APPLIED LEARNING AT SST

Paul's Wheel of Reason for Experimental Design



- Experiments should be designed using critical thinking skills.

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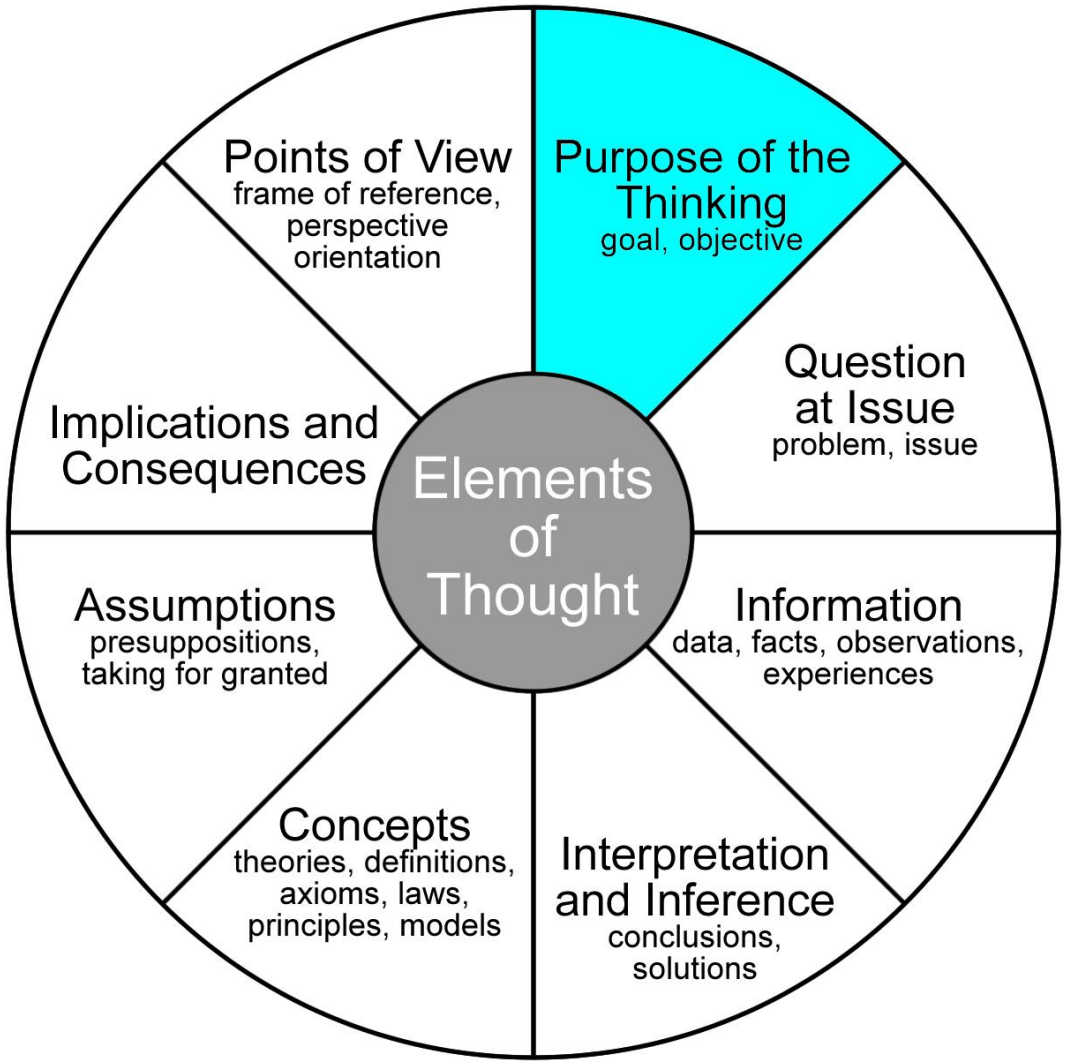
APPLIED LEARNING AT SST

Paul's Wheel of Reason for Experimental Design



- What is the reason for performing the experiment?
- What hypothesis is being proved / disproved by performing the experiment?

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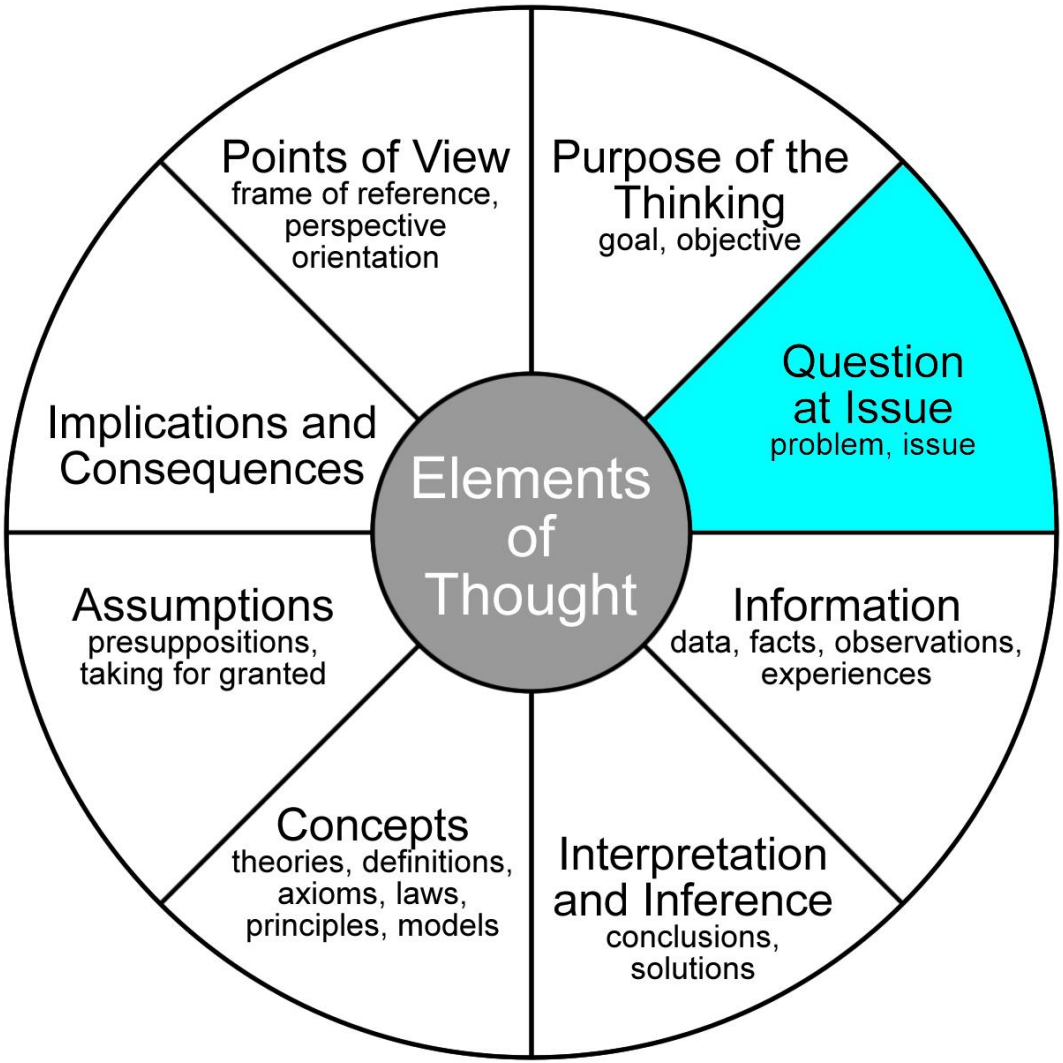
Paul's Wheel of Reason for Experimental Design



- Clearly state exactly what the experiment is being designed to do.
- What is the problem statement for the experiment?

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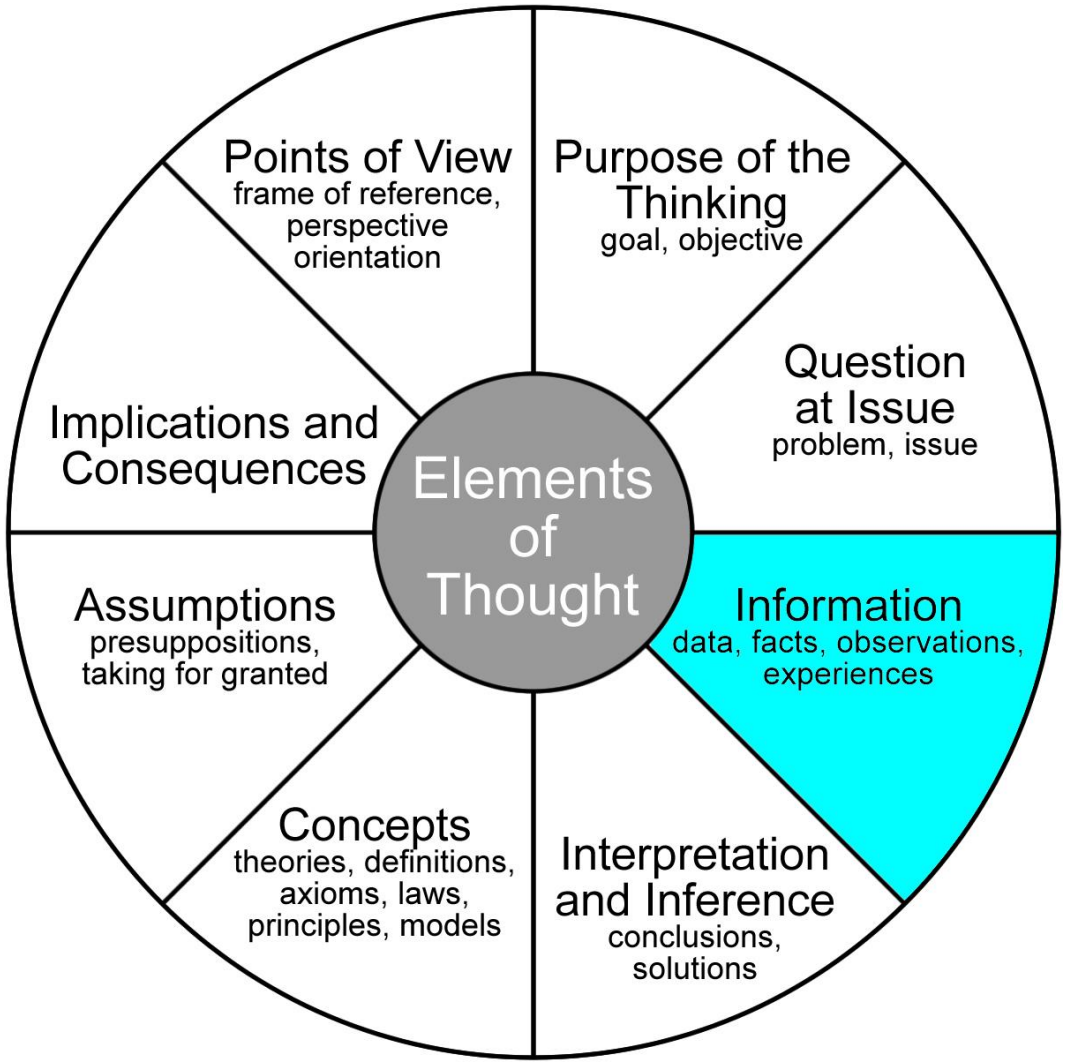
Paul's Wheel of Reason for Experimental Design



- What essential information needs to be collected by the experiment?
- What observations need to be made?
- What are the different variables (independent, dependent and control)?

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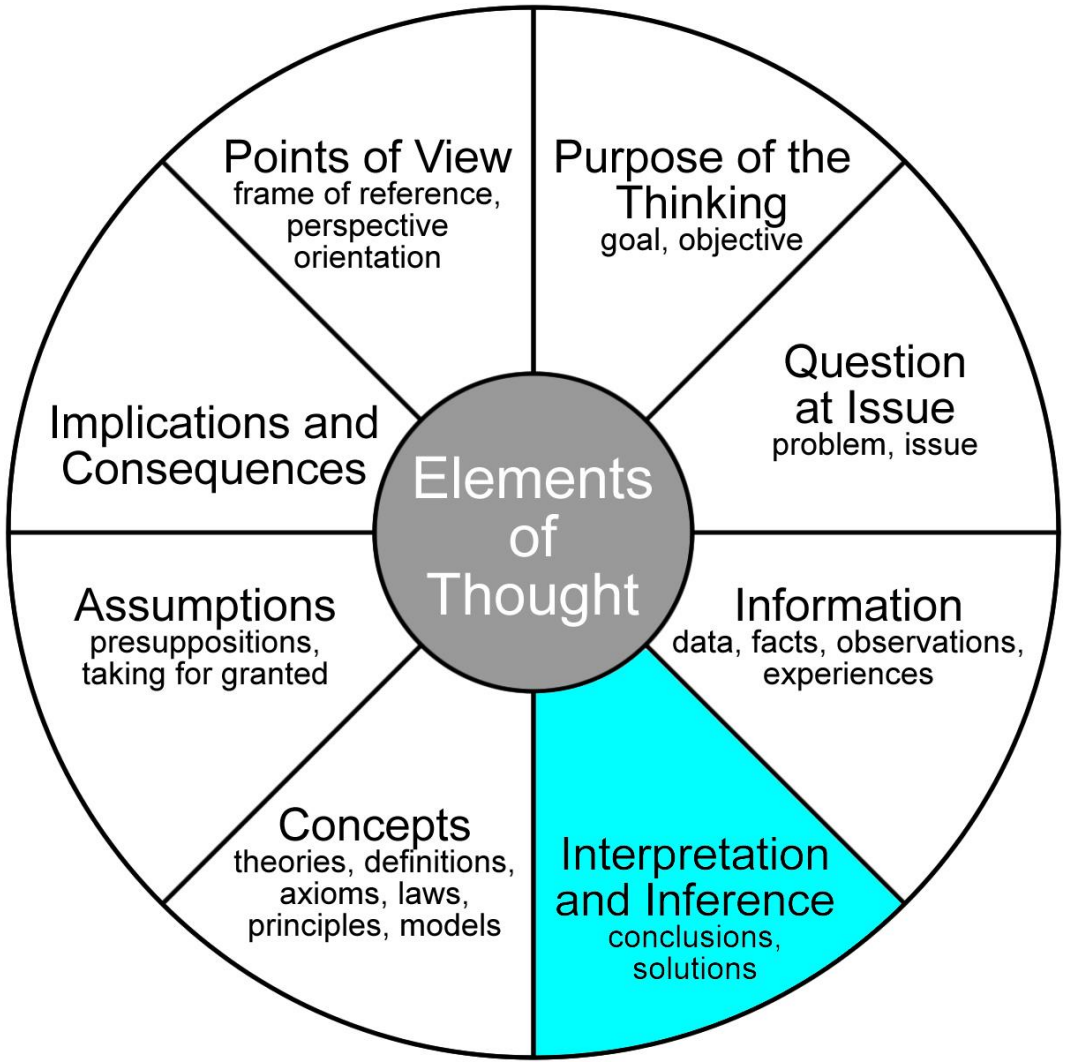
Paul's Wheel of Reason for Experimental Design



- How must the data from the experiment be manipulated and presented?
- What calculations (if any) need to be done?
- What graphs (if any) need to be plotted?

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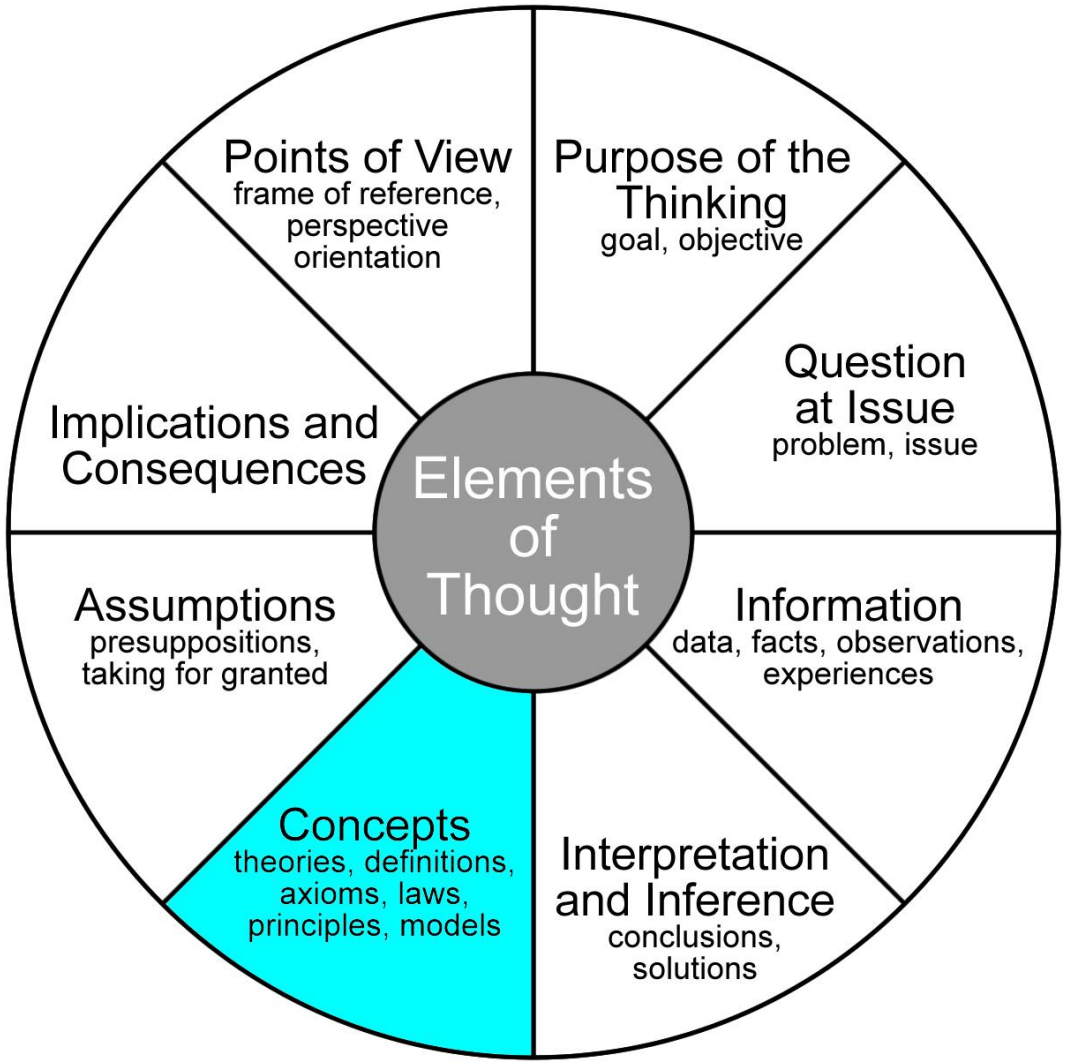
Paul's Wheel of Reason for Experimental Design



- What essential concept / law does the design of the experiment rely on? For example, the concept of energy and the law that energy can not be created or destroyed, but only converted from one form into another.

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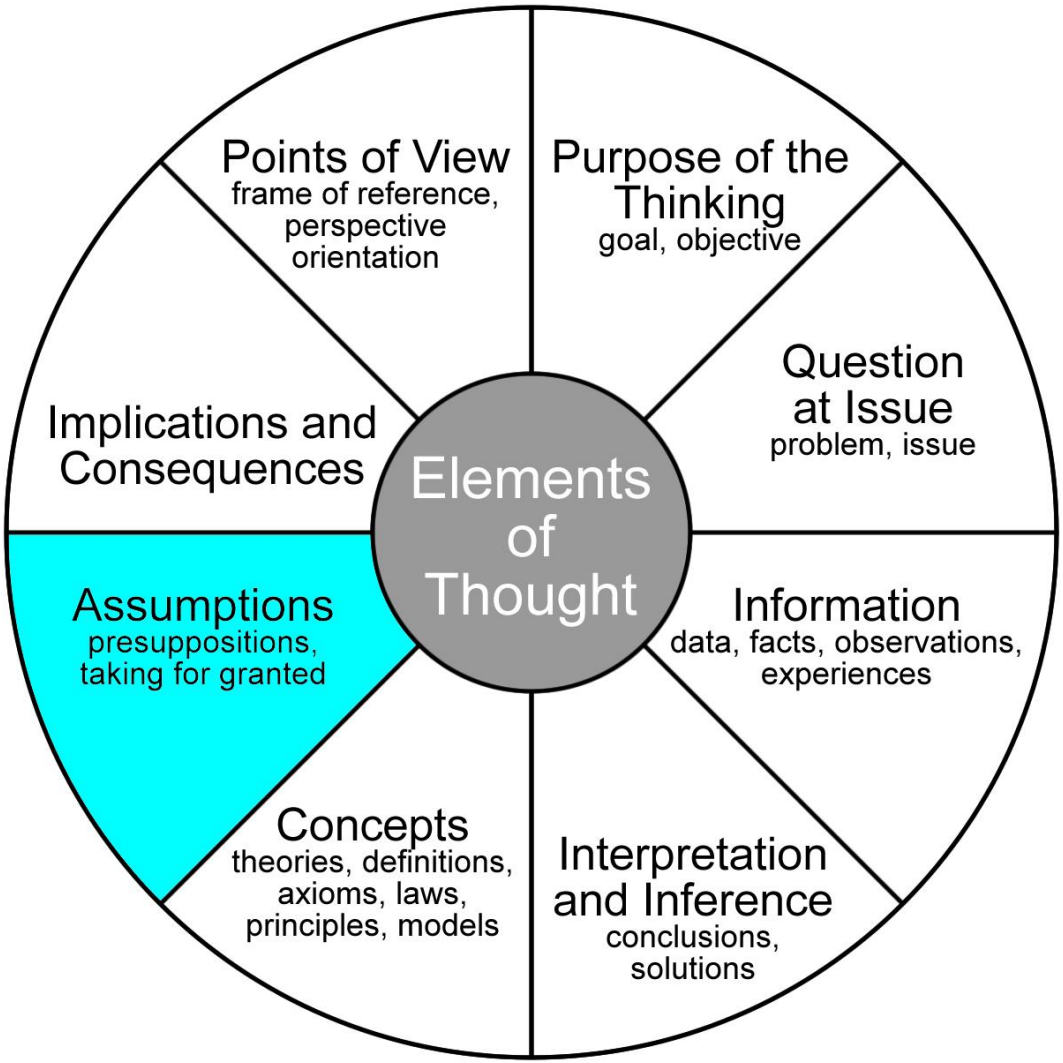
Paul's Wheel of Reason for Experimental Design



- What assumptions are being made when designing the experiment?
- Is it reasonable to make these assumptions?
- Identifying assumptions can help to identify errors.

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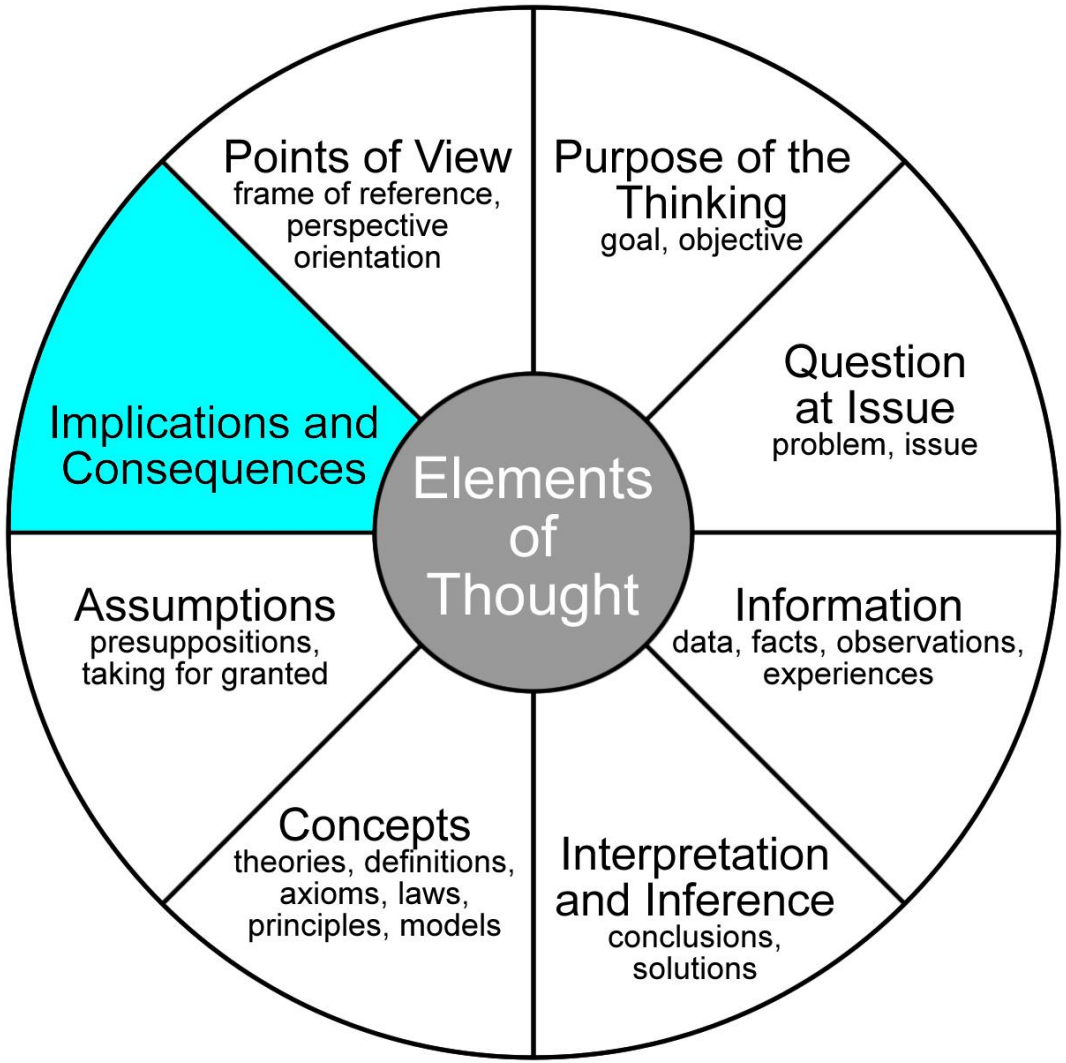
Paul's Wheel of Reason for Experimental Design



- What are the implications and consequences if the results obtained from the experiment prove / disprove a specific hypothesis?

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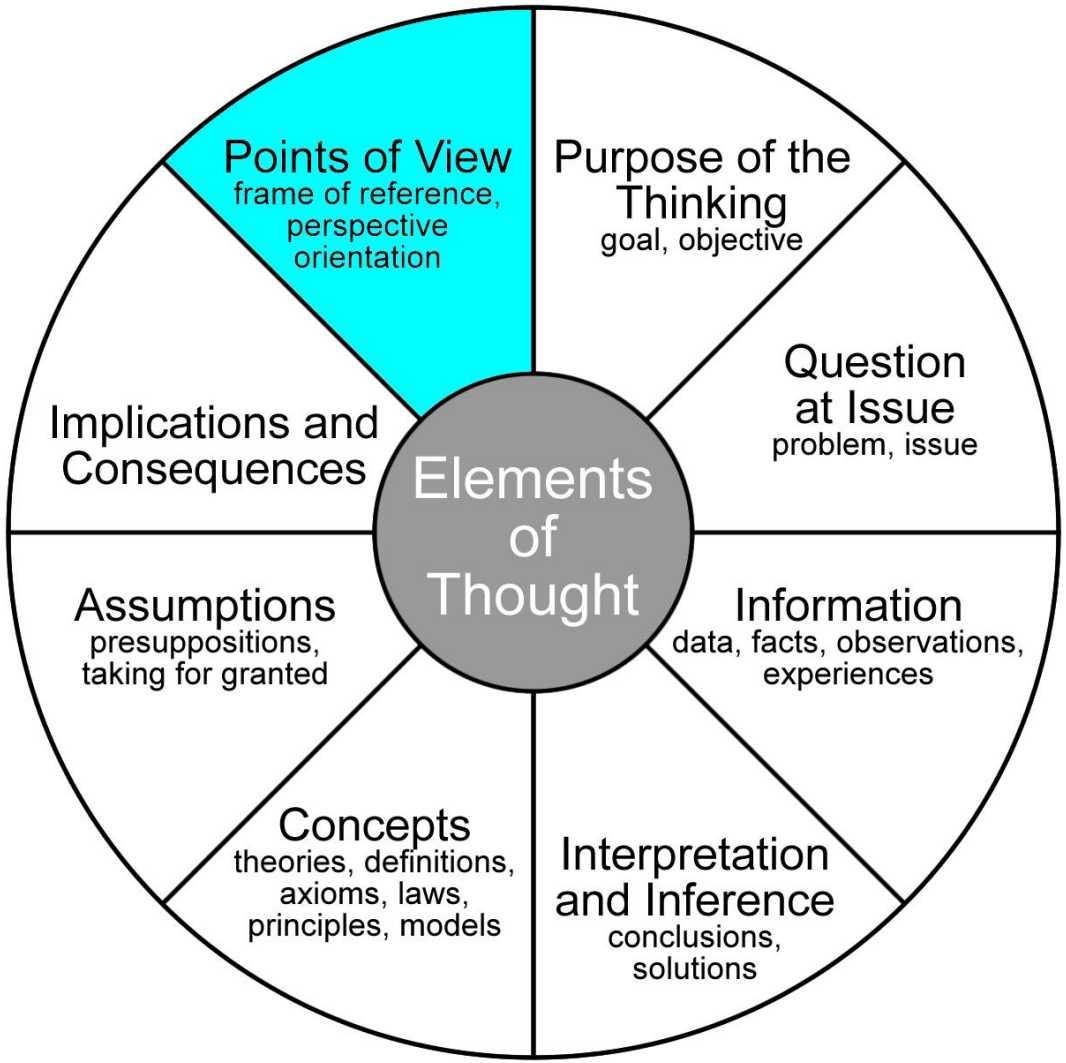
Paul's Wheel of Reason for Experimental Design



- Is there more than just one way of doing this experiment?
- If there is more than one way, which way is the most valid and reliable?

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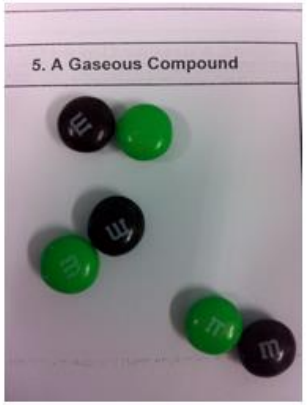
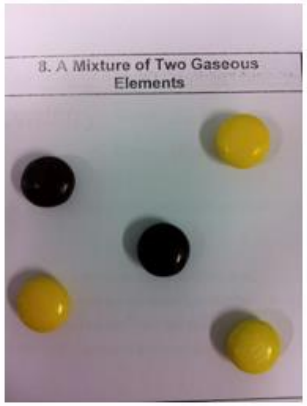
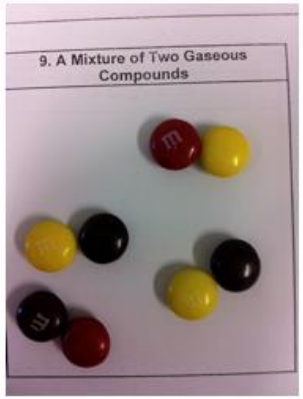
APPLIED LEARNING WITH ICT







- Secondary 3 students uses M&M's to construct models that demonstrate their understanding of elements, compounds and mixtures.

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APPLIED LEARNING WITH ICT

Concept Based Teaching

Developing the Concept of Organic Compound

What are some examples of *organic compounds* and *inorganic compounds*?

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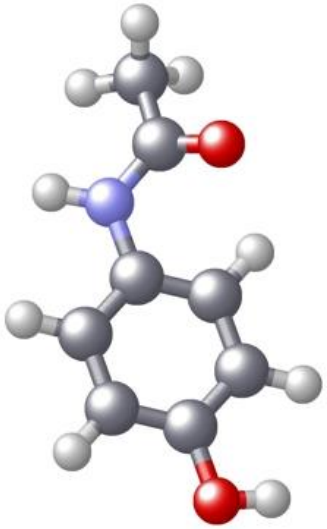
Concept Based Teaching

Developing the Concept of Organic Compound



- Students take photographs of materials that they think are organic / inorganic. The photographs are uploaded into a shared document.

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Concept Based Teaching

Developing the Concept of Organic Compound

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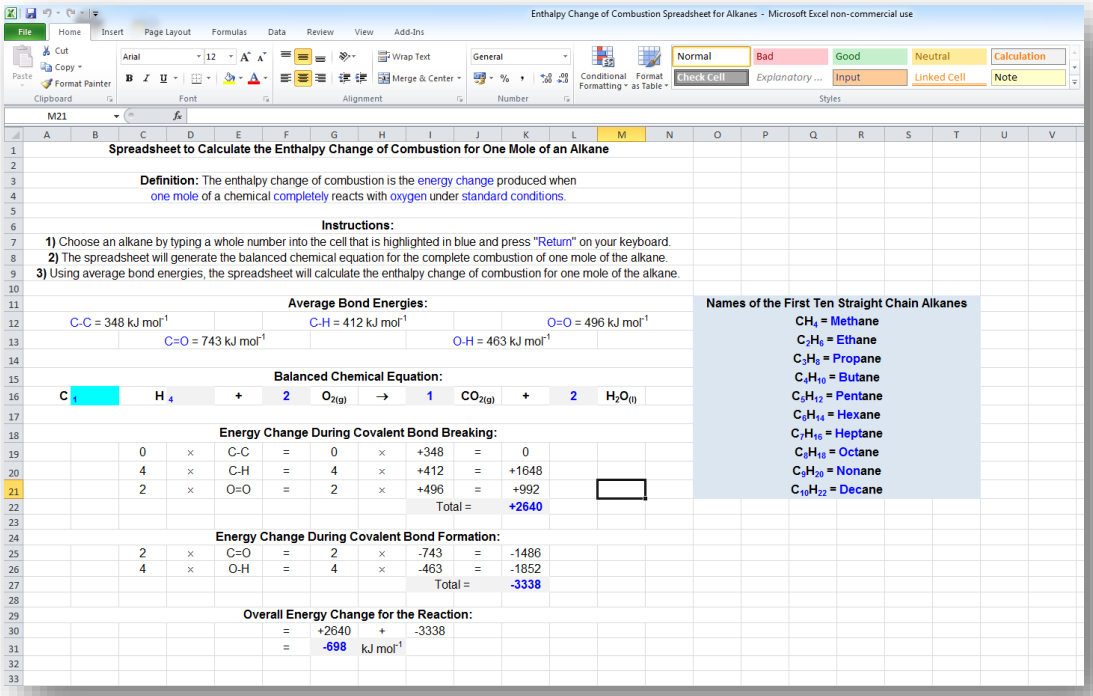
Concept Based Teaching

Developing the Concept of Organic Compound

Organic	Inorganic
$C_6H_{12}O_6$	H_2O
CH_3COOH	H_2SO_4
CH_3CH_2OH	CO_2
$-(CH_2CHCl)_n-$	NH_3
CH_4	NaCl

APPLIED LEARNING WITH ICT

- Alkanes are *hydrocarbons* with the general formula C_nH_{2n+2}.
- Alkanes react with oxygen to produce carbon dioxide and water.
- Design a *spreadsheet* that will, when the number of carbon atoms in the molecule is keyed in, automatically calculate the energy change for the combustion of one mole of an alkane.



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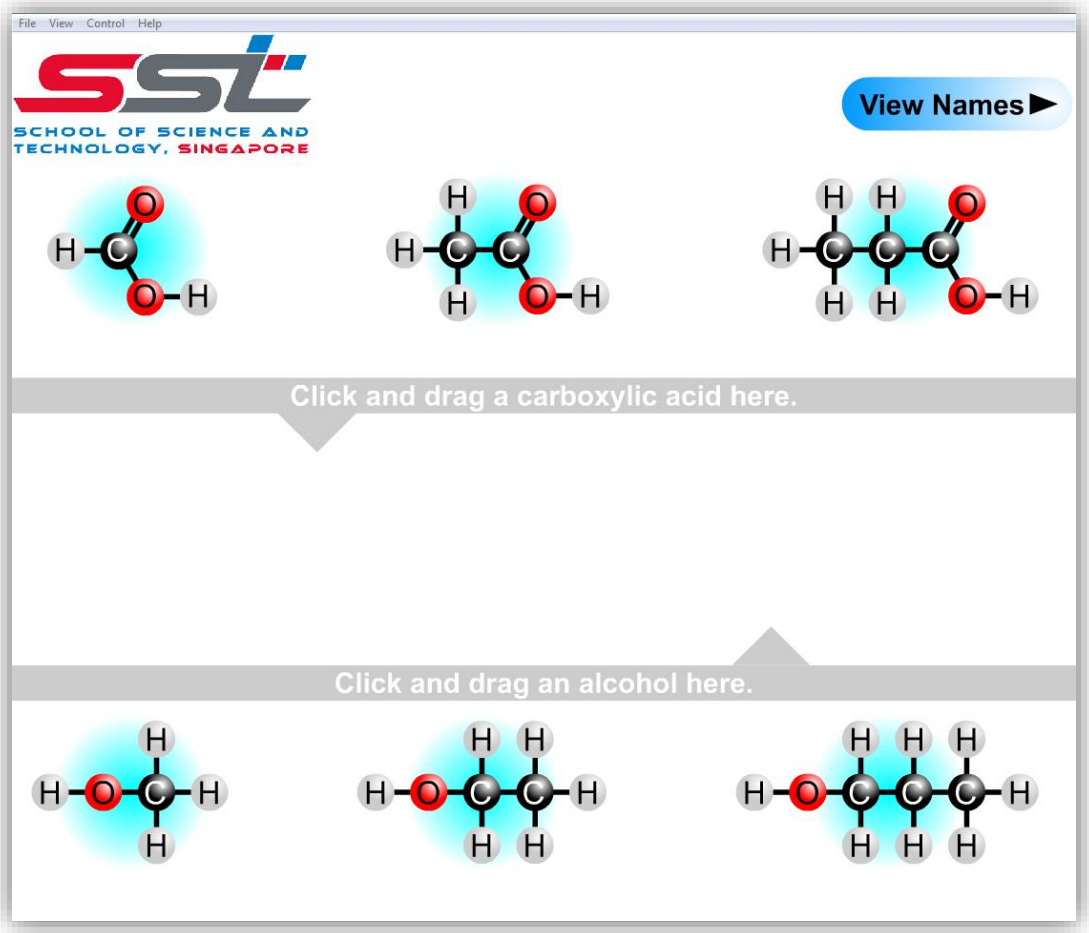
APPLIED LEARNING WITH ICT



- Interactive animations to help the students visualise and understand difficult concepts.

www.chemical.sg

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APPLIED LEARNING WITH ICT

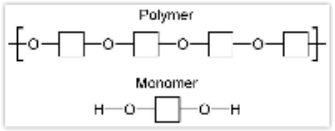
Quiz on Macromolecules

Question 4 of 15 \ Multiple Choice

A section of polymer, and the monomer that is used to make it, are shown.

Note: *Click on the diagram to enlarge it.*

The monomer undergoes condensation polymerisation. What is made each time a monomer adds to the polymer?



A) Hydrogen molecules.

B) Hydroxide ions.

C) Oxygen atoms.

D) Water molecules.

Submit

- Online platforms for learning and assessment.

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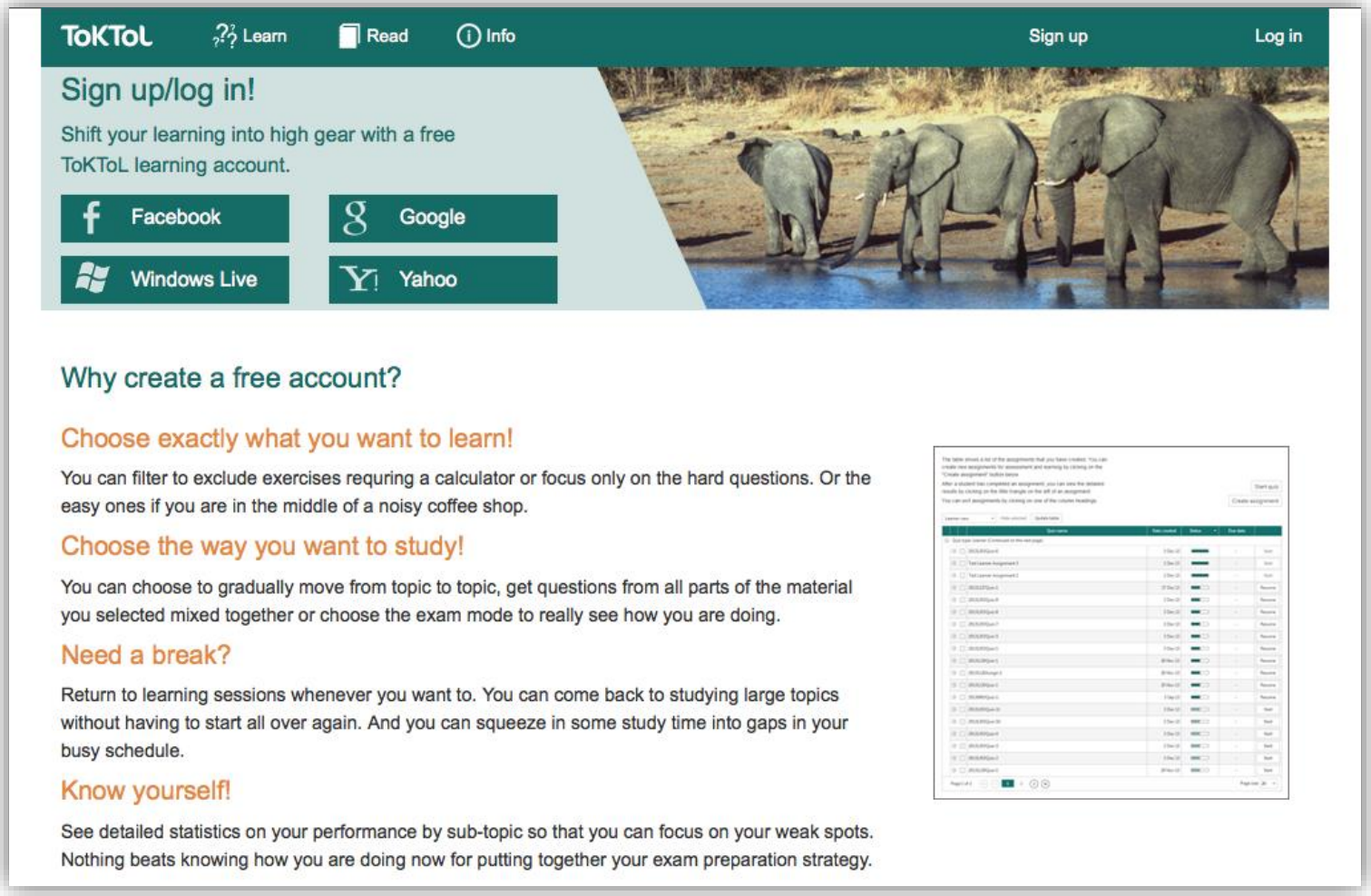

- Online platforms for learning and assessment.

www.toktol.com

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WHAT QUESTIONS DO YOU HAVE?

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APPLIED LEARNING AT SST

"We live in a society exquisitely dependent on science and technology, in which hardly anyone knows anything about science and technology."

Carl Sagan, 1934 - 1996

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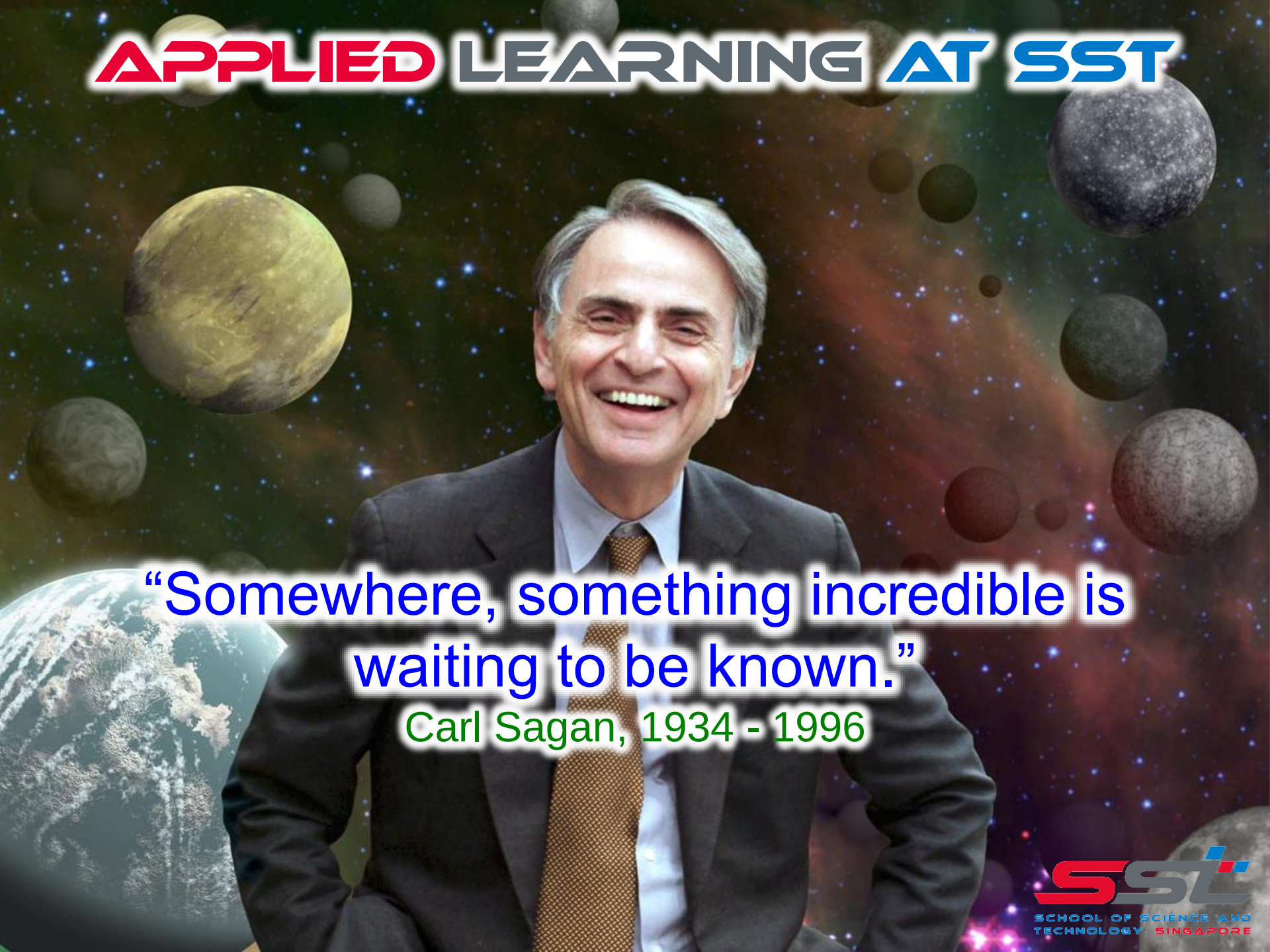
APPLIED LEARNING AT SST



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APPLIED LEARNING AT SST

"To bake the perfect apple pie from scratch, you must first invent the universe."

Carl Sagan, 1934 - 1996

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Presentation on:

Making Meaning out of Learning

The Rise of Applied Learning

For the:

Redesigning Pedagogy

International Conference – 2015

by Dr. Chris Slatter

christopher_slatter@sst.edu.sg

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