Gifted Education Branch Annual Conference

25th November 2016 – Dunman High School

Alice in Wonderland:

A Sec. One Student's Experience of an Interdisciplinary Curriculum

Benjamin Kong and Christopher Slatter
Nanyang Girls' High School

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南洋女子中學校
Nanyang Girls' High School

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- A copy of this presentation can be found online at www.scientist.sg

4) Designing a Concept Based Curriculum

Overview of Today's Presentation

The White Rabbit put on his spectacles. "Where Shall I begin, please your Majesty?" he asked.

"Begin at the beginning," the King said gravely, "and go on till you come to the end; then stop."

Alice's Adventures in Wonderland – Chapter 12

1. Rationale for a New Curriculum
2. Design of the Interdisciplinary Curriculum
3. Implementation of the Lessons
4. Implementation of the Interdisciplinary Units
5. Reflections

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Rationale for an Interdisciplinary Curriculum

Chapter One:

What were the reasons for creating a new curriculum for the Secondary One students at Nanyang Girls' High School?

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Rationale for an Interdisciplinary Curriculum

"We have to encourage [students] to bravely persist in pushing boundaries, help them to have the courage to try, fail, try again, fail again and eventually succeed."

"Students must be free to explore their passions and interests."

"Students should have an innate curiosity of wanting to know what is happening around them. How do we get our kids to be interested in many varied pursuits? They don't need to score 'A' in every subject, but to have that innate curiosity."

Mr. Ng Chee Meng (Acting Education Minister for Schools)
Reported in *Today*, 30th December 2015.

Rationale for an Interdisciplinary Curriculum

Curriculum:

In education, a curriculum is broadly defined as the totality of student experiences that occur in the educational process. The term often refers to a planned sequence of instruction, or to the student's experience based upon the school's instructional goals. Curriculum may incorporate the planned interaction of pupils with instructional content, materials, resources, and processes for evaluating the attainment of educational objectives. Curriculum may be explicit, implicit, hidden and / or co-curricular.

Kelly, A.V. (2009). *The Curriculum: theory and practice* (6th ed.). pp. 12–13. Sage.

Adams, Kathy L., Adams, Dale E. (2003). *Urban Education: A Reference Handbook*. pp. 31–32. ABC-Clio.

Rationale for an Interdisciplinary Curriculum

NYGH School Vision:

Every Nanyang girl a respected member of society.

HYGH School Mission:

We nurture women of character in a bilingual, bicultural, environment anchored in values on which our school was founded.

NYGH School Values:

- Diligence: A Nanyang girl perseveres in the pursuit of excellence.
- Prudence: A Nanyang girl exercises good judgement at all times.
- Respectability: A Nanyang girl carries herself with integrity and dignity.
- Simplicity: A Nanyang girl is sincere and humble.

Rationale for an Interdisciplinary Curriculum

Rationale for an Interdisciplinary Curriculum

- Did You Know? – 2016. What world will our students live in?
  Duration – 7 min.

Rationale for an Interdisciplinary Curriculum

- The world is a constantly changing place that is becoming increasingly unpredictable.

→ **V**olatile
→ **U**ncertain
→ **C**omplex
→ **A**mbiguous

- What type of curriculum could best prepare students for the future?

→ Anticipate the issues that shape conditions.
→ Understand the consequences of issues and actions.
→ Appreciate the interdependence of variables.
→ Prepare for alternative realities and challenges.
→ Interpret and address relevant opportunities

https://en.wikipedia.org/wiki/volatility,_uncertainty,_complexity_and_ambiguity

Rationale for an Interdisciplinary Curriculum

Rationale for an Interdisciplinary Curriculum

- Primary school students have no experience and few expectations of a Sec.1 curriculum. Sec. 1 is a good point to act and implement a new curriculum that sets a standard for the following three years.

- The main objective of the new interdisciplinary curriculum was to take the content of the existing Sec. 1 curriculum, and re-engineer it in such a way that different subjects could be linked together through common macroconcepts, thus allowing students to make interdisciplinary connections that stretched their thinking and helped them to understand how combining different subjects together could help them to better understand real world problems that are relevant to their lives.

Rationale for an Interdisciplinary Curriculum

Changes in A' Level Subjects:

- A' Level Biology, Chemistry and Physics are organised around themes (concepts) such as models and systems.
- A' Level questions that require recall are less common. Questions that require students to analyse, synthesise and apply their knowledge to solve authentic problems are now more common.
- A' Level exam questions are becoming broader and drawing on knowledge from different disciplines. For example, dropping a ball bearing through a column of milk to determine whether or not the milk has been diluted with water – is the subject that is being assessed Biology, Chemistry or Physics?

Rationale for an Interdisciplinary Curriculum

Wish List for the Secondary One Interdisciplinary Curriculum:

- 21st Century Skills – cooperation, collaboration, communication, STEAM, maker education, information communication technology.
- Driven by the concept of sustainability that will spiral from Sec. 1 to Sec. 4.
- Integrate subjects generating meaningful connections.
- Failure is acceptable, but strive for success!
- Develop critical and creative thinking skills.
- Authentic, applied and relevant.
- Interesting and engaging.

Designing the Interdisciplinary Curriculum

Chapter Two:

How was the interdisciplinary curriculum designed?

Designing the Interdisciplinary Curriculum

Back to the drawing board!

Nanyang Girls' High School

Designing the Interdisciplinary Curriculum

- A core team of teachers – made-up of a representative from each department – met with the Vice-Principal (Academic) and Dean (Curriculum) once-a-week for two hours each time. These meetings were formally timetabled from the beginning of the year.

- Time to meet with the Sec. 1 subject teachers was "borrowed" from other meetings, *e.g.* Department meetings and Level meetings. Sec. 1 subject teachers met, on average, once every fortnight for one hour.

Designing the Interdisciplinary Curriculum

Ideas:

- Understanding by Design
  - → Begin with the end in mind.
- Parallel Curriculum Model
  - → Core curriculum.
  - → Curriculum of connections.
  - → Curriculum of practice.
  - → Curriculum of identity.
- Concept based teaching and learning.
- Design Thinking
- Habits of Mind
- Modes of Assessment
- Critical Thinking
- De Bono's Six Hats
- Disciplinary Literacy

Designing the Interdisciplinary Curriculum

What is a Concept?

- A concept is:

→ A general idea.

→ Which represents a class of people, items, actions or relationships.

→ Having certain defined characteristics.

Designing the Interdisciplinary Curriculum

Elements of a Concept

- Name.
- Critical attributes (essential characteristics of the concept).
- Value range of the critical attributes (acceptable variation of the characteristics).
- Examples.
- Non-examples.

Designing the Interdisciplinary Curriculum

For Learners:

- Research has shown that the human brain seeks to structure information.
- Concept based learning allows the brain to:

→ Organise information.

→ Accommodate new information.

→ Retain key information better in the long-term.

Designing the Interdisciplinary Curriculum

Objectives:

- Teachers use macroconcepts to design their units.
- Generalisations (enduring understandings) about the macroconcepts allow teachers to make meaningful connections between different subjects for the students.
- Essential questions about the macroconcepts are similar for the different subjects, allowing further connections to be made.

Designing the Interdisciplinary Curriculum

Macro-concept: Sustainability

Sec Two Sustainable Community
Sec One Sustainable Living

Designing the Interdisciplinary Curriculum

- Introduction to Disciplinary Studies through the use of micro-concepts and macro-concepts.

- Introduction to Interdisciplinary Studies using macro-concepts.

Change	**Communication**	**Evidence**
Model	**System**	**Sustainability**

Designing the Interdisciplinary Curriculum

"Children must be taught *how* to think,
not *what* to think."

Margret Mead

- Macro-concept: Sustainability

- Focus for Sec. 1: Working in groups, students explore the idea of sustainable living.

- Garden to Table → Basic need – Food (System)

- The Built Environment → Basic need – Shelter (Model)

Designing the Interdisciplinary Curriculum

Coverage Centred	Idea Centred
"Inch deep and mile wide."	Facts provide a foundation to understand conceptual / transferable ideas.
Intellectually Shallow Lacks conceptual focus to create factual / conceptual brain synergy.	**Intellectually Deep** A "conceptual lens" or focus requires mental processing on the factual and conceptual levels. This results in producing intellectual depth in thinking and understanding.

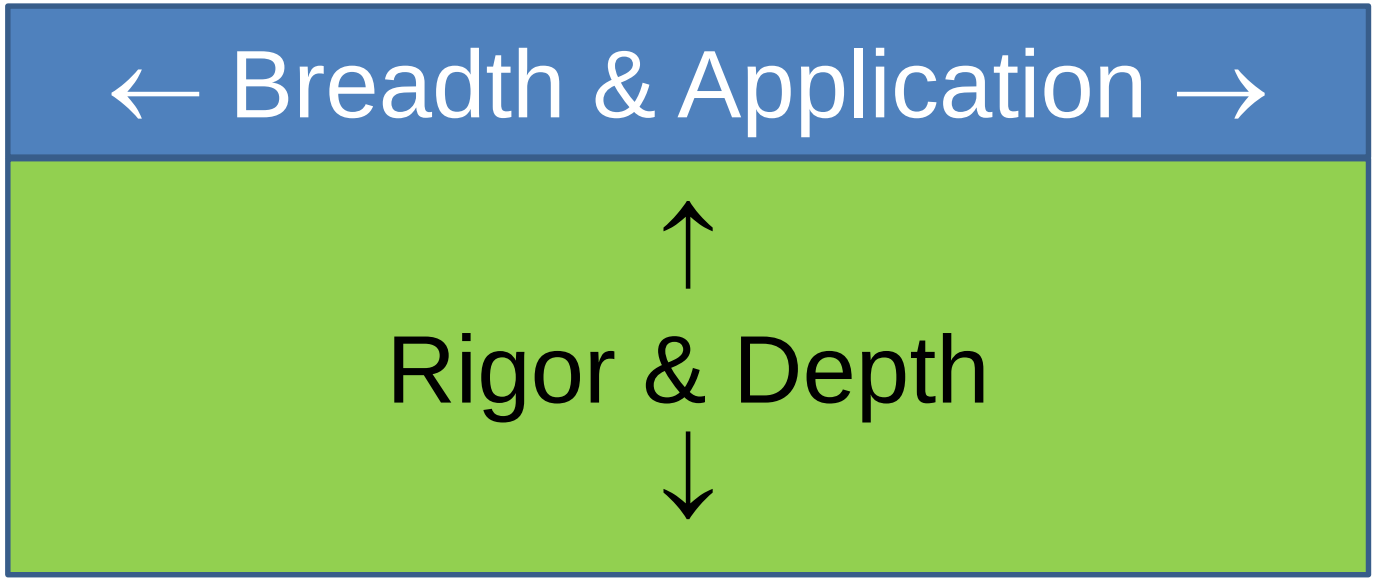
Designing the Interdisciplinary Curriculum

Coverage Centred	Idea Centred
Fails to Allow for Transfer No transfer of understanding. Facts are locked in time, places or situations.	**Concepts and Generalisations Transfer** Allows the brain to see patterns and make connections.
Fails to meet intellectual demands of the 21st Century e.g. critical and creative thinking, flexibility, making connections, finding alternative ways to solve problems.	**Develops the intellect to handle a world of increasing complexity and accelerating change.**

Designing the Interdisciplinary Curriculum

Best of Both Worlds

- Macro-concepts and application similar to the International Baccalaureate curriculum.
- Micro or disciplinary concepts and disciplinary literacies similar to the A' Level curriculum.



Designing the Interdisciplinary Curriculum

- Change

→ Change can be steady, cyclic or random.

→ Why do people / systems resist change?

- Communication

→ Communication is essential for progress.

→ What assumptions are made when communicating?

- Evidence

→ Evidence is open to interpretation.

→ What can be accepted as evidence?

Designing the Interdisciplinary Curriculum

- **Model**

→ Models simulate real world processes.

→ How reliable are models? Limitations of models?

- **System**

→ Systems follow rules.

→ Who / what defines the rules?

- **Sustainability**

→ A system supports and renews itself indefinitely.

→ How can conflicts between progress and sustainability be resolved?

Nanyang Girls' High School - Secondary One Curriculum 2016

Teaching Week:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Biology	Nature of Science (2) Communication and Evidence		Cell Structure (6) Macroconcept: Systems supported by Models						Transport Across Membranes (6) Macroconcept: Change supported by Systems						Digest Macroc		
Chemistry	Nature of Science (2) Communication and Evidence		Elements, Compounds and Mixtures (6) Macroconcept: Evidence supported by Models						Kinetic Particle Theory (4) Macroconcept: Change supported by Models				Separation Techniques (3) Macroconcept: Change supported by Systems			A Macroconc	
Physics	Nature of Science (2) Communication and Evidence		Measurement (12) Macroconcept: Evidence												Energy (3) Macroconcept: Syste		

Chemistry Version Two:									Separation Techniques (3) Macroconcept: Change supported by Systems				Kinetic Particle Theory (4) Macroconcept: Change supported by Models				
Physics Version Two:															Kinetic Particle Theory Macroconcept: Chan supported by Mode		

Math	Nature of Mathematics (1) Communication and Evidence		Numbers (4) Macroconcept:Systems			Algebra (2) Macroconcept:Communication and Change		Statistics (3) Macroconcept:Evidence and Communication			Numbers (2) Macroconcept:System		Spatial Sense (4) Macroconcept:Communication				Macr
History	Nature of History (2) Communication and Evidence		How old is Singapore? (8) Macroconcept: Evidence						Why did people come to colonial Singapore before World War Two? (5) Macroconcept: Change (Causation)						How was life diffe Singapore befo Macroconce		
Geography	**Nature of Geography (2)Communication and Evidence**		**Introduction to Weather and Climate, GI (8)Macroconcept:Systems, Models and Change**						**Natural vegetation (5)Macroconcept:Environment, Space, Interdependence**						**Energy Resou (5)Macro**		
English Language	Nature of En		**Personal Expression: Personal Recounts, Storytelling, I**					Poetry & Literary Respon Macroconcept:		**Reading Compre**		**FPS & Narrative**		**Short Stories: GI**		**Drama and L**	
Chinese Language	Nature of Chinese (2) Communication and Evidence		Narrative Prose Unit 1 (3) 把事说清楚 Macroconcept: Change, Systems, Communications			Expository Prose Unit 1 (3) 知识万花筒 Macroconcept: Systems, Communications, Evidence , Environment, Culture			Narrative Prose Unit 2 (3) 把人写活了 Macroconcept: Change, Systems, Communications, Evidence, Character			Expository Prose Unit 2 (3) 我眼观天下 Macroconcept: Change, Systems, Communications, Evidence			Narrative Prose Unit 3 真情流露 Macroconcept: Chan Systems, Communications, Evidence, Characte		

Nanyang Girls' High School - Secondary One Curriculum 2016

3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Cell Structure (6) Macroconcept: Systems supported by Models						Transport Across Membranes (6) Macroconcept: Change supported by Systems						Digestive System (6) Macroconcept: Systems					
Elements, Compounds and Mixtures (6) Macroconcept: Evidence supported by Models						Kinetic Particle Theory (4) Macroconcept: Change supported by Models				Separation Techniques (3) Macroconcept: Change supported by Systems			Atomic Structure (5) Macroconcept: Evidence supported by Models				
Measurement (12) Macroconcept: Evidence												Energy (3) Macroconcept: Systems			Kinetic Particle Theory (3) Macroconcept: Change supported by Models		

Chemistry Version Two:						Separation Techniques (3) Macroconcept: Change supported by Systems			Kinetic Particle Theory (4) Macroconcept: Change supported by Models								
Physics Version Two:												Kinetic Particle Theory (3) Macroconcept: Change supported by Models			Energy (3) Macroconcept: Systems		

Numbers (4) croconcept:Systems		Algebra (2) Macroconcept:Communication and Change		Statistics (3) Macroconcept:Evidence and Communication			Numbers (2) Macroconcept:System		Spatial Sense (4) Macroconcept:Communication				Algebra (5) Macroconcept:Communication and Change				
How old is Singapore? (8) Macroconcept: Evidence						Why did people come to colonial Singapore before World War Two? (5) Macroconcept: Change (Causation)						How was life different among the people in Singapore before World War Two? (5) Macroconcept: Systems (Social)					
Introduction to Weather and Climate, GI (8)Macroconcept:Systems, Models and Change						**Natural vegetation (5)Macroconcept:Environment, Space, Interdependence**						**Energy Resources, Climate Change (5)Macroconcept:Systems**					
Expression: Personal Recounts, Storytelling, I				Poetry & Literary Respon Macroconcept:		**Reading Compre**		**FPS & Narrative**		**Short Stories: GI**		**Drama and Literary Analysis: The**					REVISIO
Narrative Prose Unit 1 (3) 把事说清楚 Macroconcept: Change, Systems, Communications		Expository Prose Unit 1 (3) 知识万花筒 Macroconcept: Systems, Communications, Evidence , Environment, Culture				Narrative Prose Unit 2 (3) 把人写活了 Macroconcept: Change, Systems, Communications, Evidence, Character			Expository Prose Unit 2 (3) 我眼观天下 Macroconcept: Change, Systems, Communications, Evidence			Narrative Prose Unit 3 (3) 真情流露 Macroconcept: Change, Systems, Communications, Evidence, Character			Arguementative Unit 1 (3) 有话好好说 Macroconcept: Change, Systems, Communications, Evidence		

Designing the Interdisciplinary Curriculum

Assessment

- Less emphasis on written examinations.
- Focus on student development rather than their grade.
- Make use of formative assessments to track progress.
- Use a variety of assessment techniques, presentations, interviews, journaling, practicals, online quizzes.

Designing the Interdisciplinary Curriculum

Assessment

- CA1 = 40% (Online “live” system).
- CA2 = 30% (may be integrated into the IDU).
- SA = 30% (May or may not be a written examination).

Designing the Interdisciplinary Curriculum
Designing the Interdisciplinary Units

- The core curriculum was suspended for seven weeks to allow implementation of the Two Interdisciplinary Units.
- The Interdisciplinary Units ran for three weeks before the June holiday, and four weeks after the June holiday, the fourth week being used mainly for assessment.
- The Interdisciplinary Units required the students to cooperate and collaborate while researching and offering possible solutions to authentic problems. The students went on learning journeys, listened to invited speakers, attended mass lectures and conducted unusual experiments. The final event was an exposition in the school hall.

Designing the Interdisciplinary Curriculum
Designing the Interdisciplinary Units

- Original ideas for possible interdisciplinary units:

→ Built Environment

→ Chinese Literature

→ Climate Change

→ Crime Scene Investigation

→ Garden-to-Table

→ Health and Medicine
(modern medicine & traditional Chinese medicine)

Designing the Interdisciplinary Curriculum
Designing the Interdisciplinary Units

- Garden to Table

→ Consider the geography and history of agriculture.
→ What are the optimum conditions for plant growth?
→ Consider human diet and nutrition.
→ In a city environment, is it possible for an individual to feed herself?

- The Built Environment

→ How does architecture change with culture?
→ How does nature influence architecture?
→ Can truly eco-friendly buildings ever be a reality?
→ What are the limitations of architecture?

- The Climate and Us

→ How does humanity affect the climate?
→ How does the climate affect humanity?
→ How can an individual / society adapt to a change in climate?

Designing the Interdisciplinary Curriculum
Designing the Interdisciplinary Units

- Garden to Table

→ Consider the geography and history of agriculture.
→ What are the optimum conditions for plant growth?
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- ~~The Climate and Us~~

→ ~~How does humanity affect the climate?~~
→ ~~How does the climate affect humanity?~~
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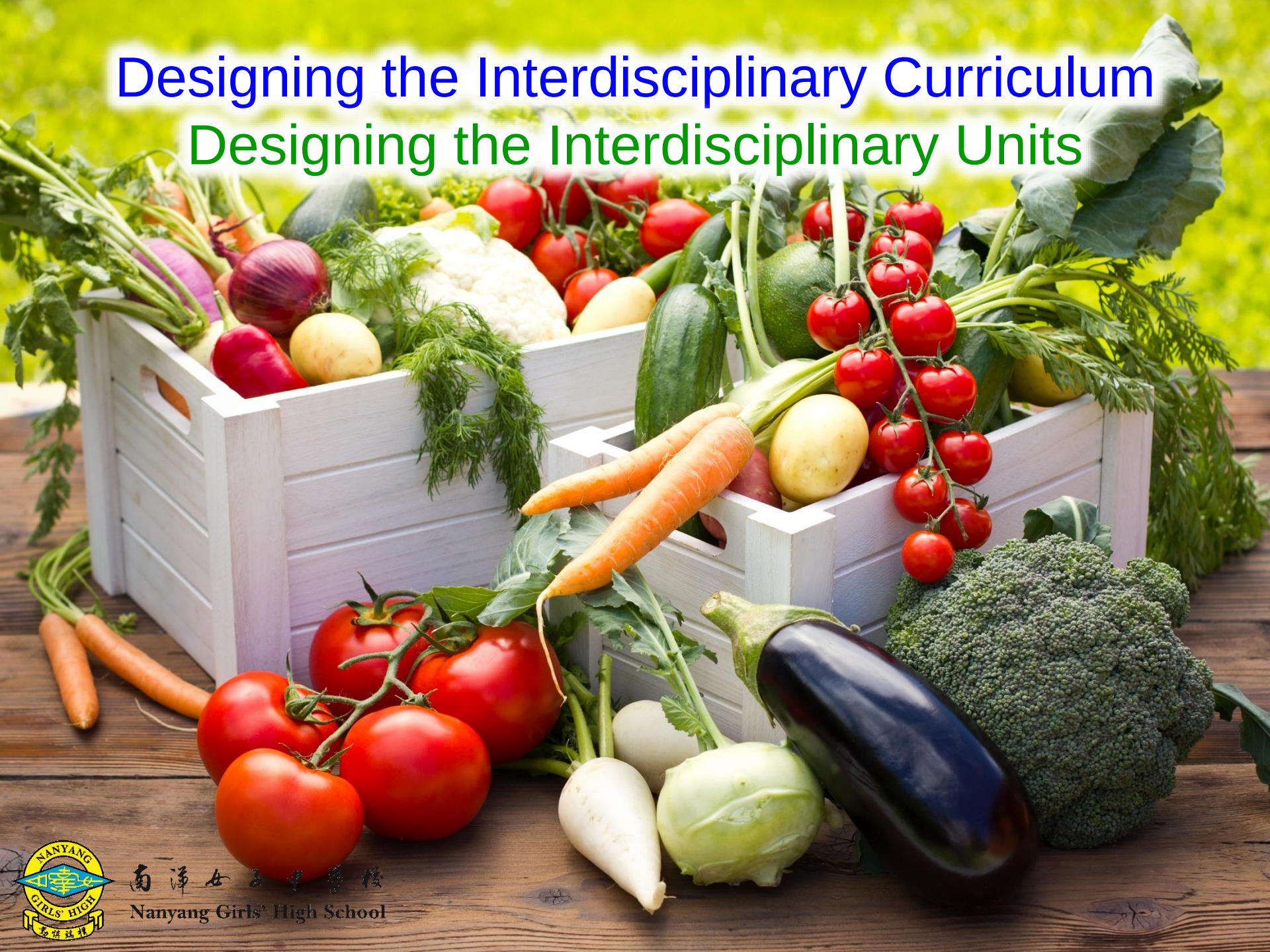
Designing the Interdisciplinary Curriculum

Designing the Interdisciplinary Units



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Designing the Interdisciplinary Curriculum
Designing the Interdisciplinary Units

Interdisciplinary Unit

Garden to Table

Addressing a Basic Human Need

Food – sustainable agriculture

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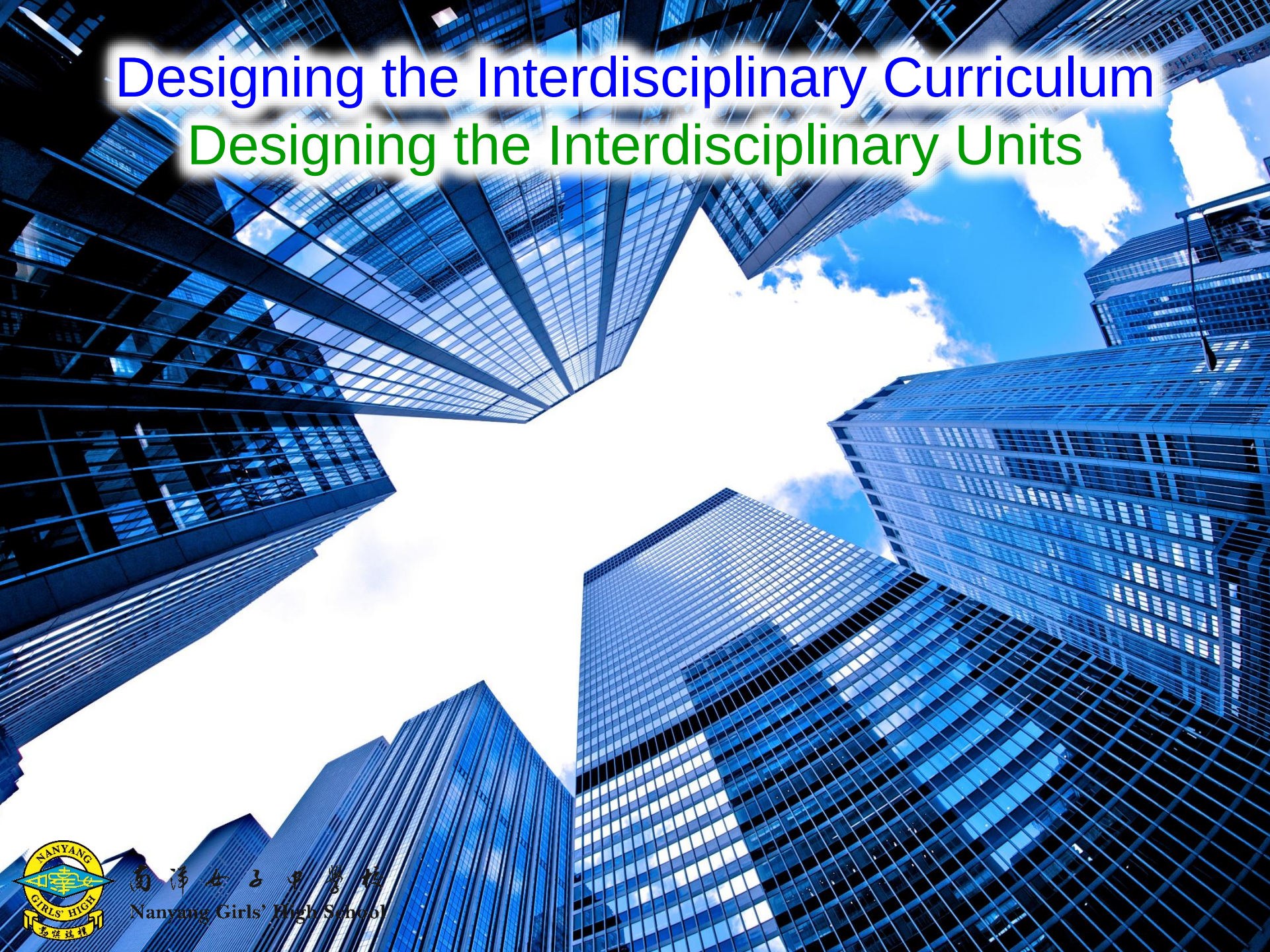
Designing the Interdisciplinary Curriculum

Designing the Interdisciplinary Units

- Where does our food come from?
- How much food is wasted? Where does it go to?
- Why is certain land used for farming, but not others?
- Who grows our food, and what are their stories?
- How has farming changed over time, and what is its future?
- How do farming practices vary around the world?
- How can the food industry meet the needs of the increasing world population?
- Is the food industry sustainable?

Designing the Interdisciplinary Curriculum

Designing the Interdisciplinary Units



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Designing the Interdisciplinary Curriculum
Designing the Interdisciplinary Units

Interdisciplinary Unit

The Built Environment

Addressing a Basic Human Need

Shelter – sustainable buildings

Designing the Interdisciplinary Curriculum

Designing the Interdisciplinary Units

- What is the built environment?
- Who / what is the built environment made for?
- What is the built environment made of?
- Who designs / constructs the built environment, and what are their stories?
- How has the built environment changed over time?
- How does the built environment change around the world?
- Can the built environment and nature live in harmony?
- Is the built environment sustainable?

Designing the Interdisciplinary Curriculum
Designing the Interdisciplinary Units

Grouping the Students

- For the duration of the interdisciplinary units, students worked together in groups of four-to-five members.

- As far a possible, form teachers were responsible for grouping and mentoring their own students.

→ Teachers allowed the students to group themselves.
→ Teachers assigned individual students to specific groups based upon their knowledge of the student.
→ Teachers grouped the students randomly using the students' class index numbers.

Designing the Interdisciplinary Curriculum
Designing the Interdisciplinary Units

Scenario for the Interdisciplinary Units

- The year is 2036. Nanyang Girls' High School is the first school to be awarded the Urban Redevelopment Authority's sustainable living award.
- As the winner of this award, the school has to organise an exposition to communicate its winning ideas to the general public.
- Your group (4 – 5 students) has been selected to present its winning project at the exposition.
- Use the past and present to predict the future.

Designing the Interdisciplinary Curriculum
Designing the Interdisciplinary Units

Create Opportunities for Students to:

- Develop a meaningful understanding of complex associations and influences within specific concepts.
- Make decisions, think critically and creatively as well as synthesize knowledge beyond the disciplines.
- Identify, assess and transfer significant information needed for solving novel problems.
- Embrace cooperative learning and a better attitude towards oneself as a learner and a meaningful member of a community.

Designing the Interdisciplinary Curriculum

Designing the Interdisciplinary Units

Timeline for the Interdisciplinary Units

- Term 2 Week 8 – Lessons
- Term 2 Week 9 – Lessons and Learning Journey
- Term 2 Week 10 – Lessons

June Vacation

- Term 3 Week 1 – Lessons
- Term 3 Week 2 – Lessons
- Term 3 Week 3 – Lessons
- Term 3 Week 4 – Assessment (presentations and exposition)

Designing the Interdisciplinary Curriculum
Designing the Interdisciplinary Units

- *Design Thinking* is a way of looking at how to improve people's lives. It involves going through a process of understanding people, discovering needs, envisioning a better life, and making it a reality.

- *Design Thinking* is *not* simply solving a problem, nor is it about making things "fancy."

Designing the Interdisciplinary Curriculum
Designing the Interdisciplinary Units

The Five Phases of Design Thinking

E.D.I.C.T.

Empathise	Define	Ideate	Create a Prototype	Test
Learn about your audience or customer.	**Think** about what will help your audience or customer live a better life.	**Ideate** ideas on improving what you have chosen.	**Think** about how to show your ideas of improvement to others.	**Test** the extent to which your idea meets the needs of your audience or customer.

Designing the Interdisciplinary Curriculum
Designing the Interdisciplinary Units

Online Learning Community for the IDUs

- A one-stop station for critical and supplementary learning resources that will help students cope and extend their learning across multiple disciplines.

- A blended learning environment supporting students' learning in both online and physical environments, pooling together collective knowledge and facilitating learning and communication.

Designing the Interdisciplinary Curriculum

Designing the Interdisciplinary Units

Assessment and Rubrics

Assessment Objective	Weighting	Stage in IDU
Objective 1	50%	Process
Objective 2	20%	Presentation
Objective 3	30%	Product

- Process Rubrics Based on Design Thinking – assessed by Teacher Mentors.
- Presentation Rubrics – oral presentation assessors.
- Product Rubrics – Exposition Team.

Designing the Interdisciplinary Curriculum
Designing the Lessons

Journal Writing

- Language Arts will teach the students journaling skills.
- Students will have one journal which they will use for all subjects.
- Teachers have the option of reading and grading the students' journal entries – but this may influence what the girls write.
- An alternative approach is for the students to write reflections and questions on Post-It notes, which may named or anonymous. These may be collected or posted on the classroom wall for other students and subject teachers to read.

Implementing the Interdisciplinary Lessons

Chapter Three:

How were the interdisciplinary lessons implemented by the teachers?

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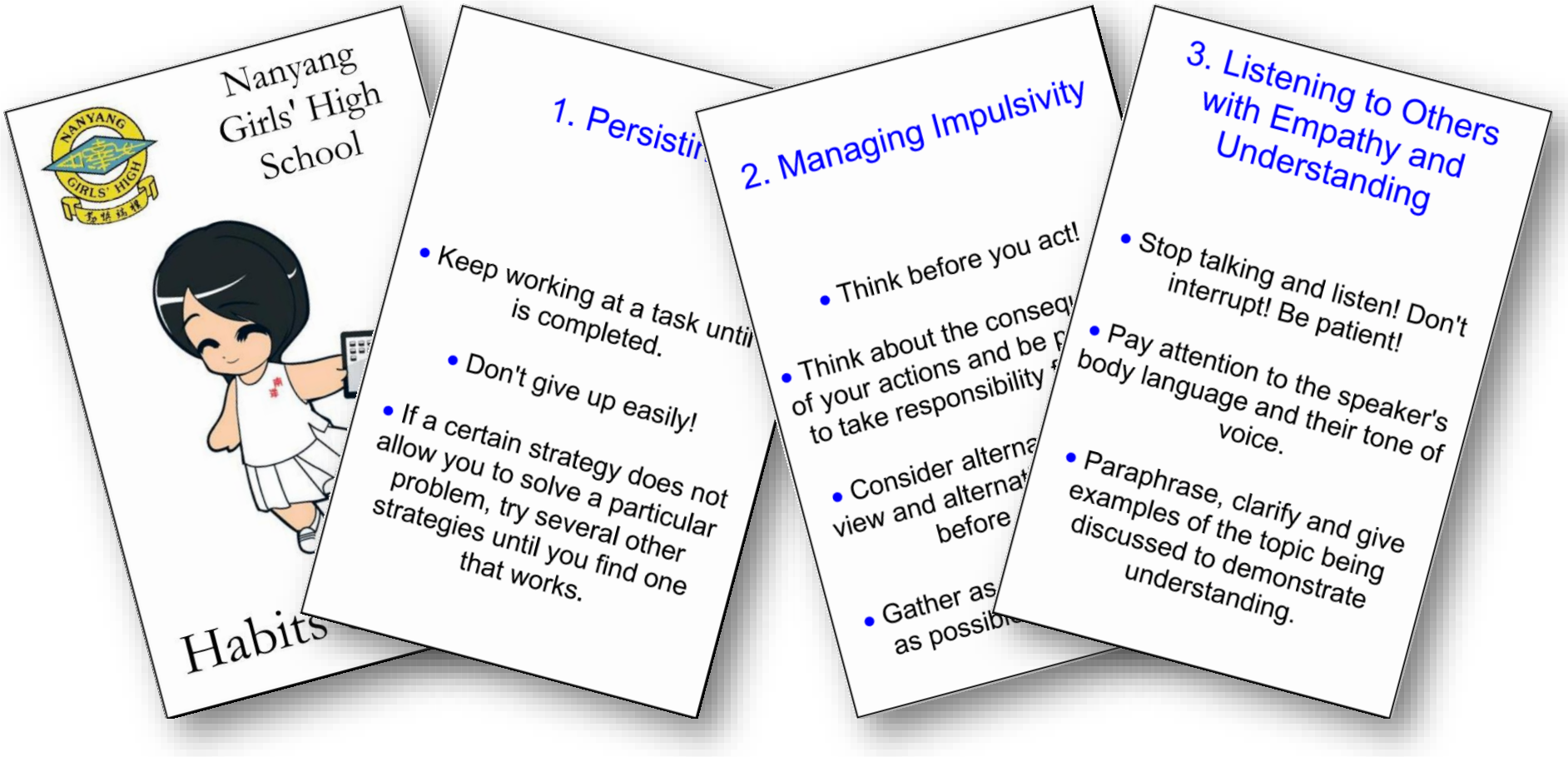
Implementing the Interdisciplinary Lessons



- Habits of Mind cards given to teachers and students.

Implementing the Interdisciplinary Lessons

- Elements of Thought and Intellectual Standards cards given to teachers and students.

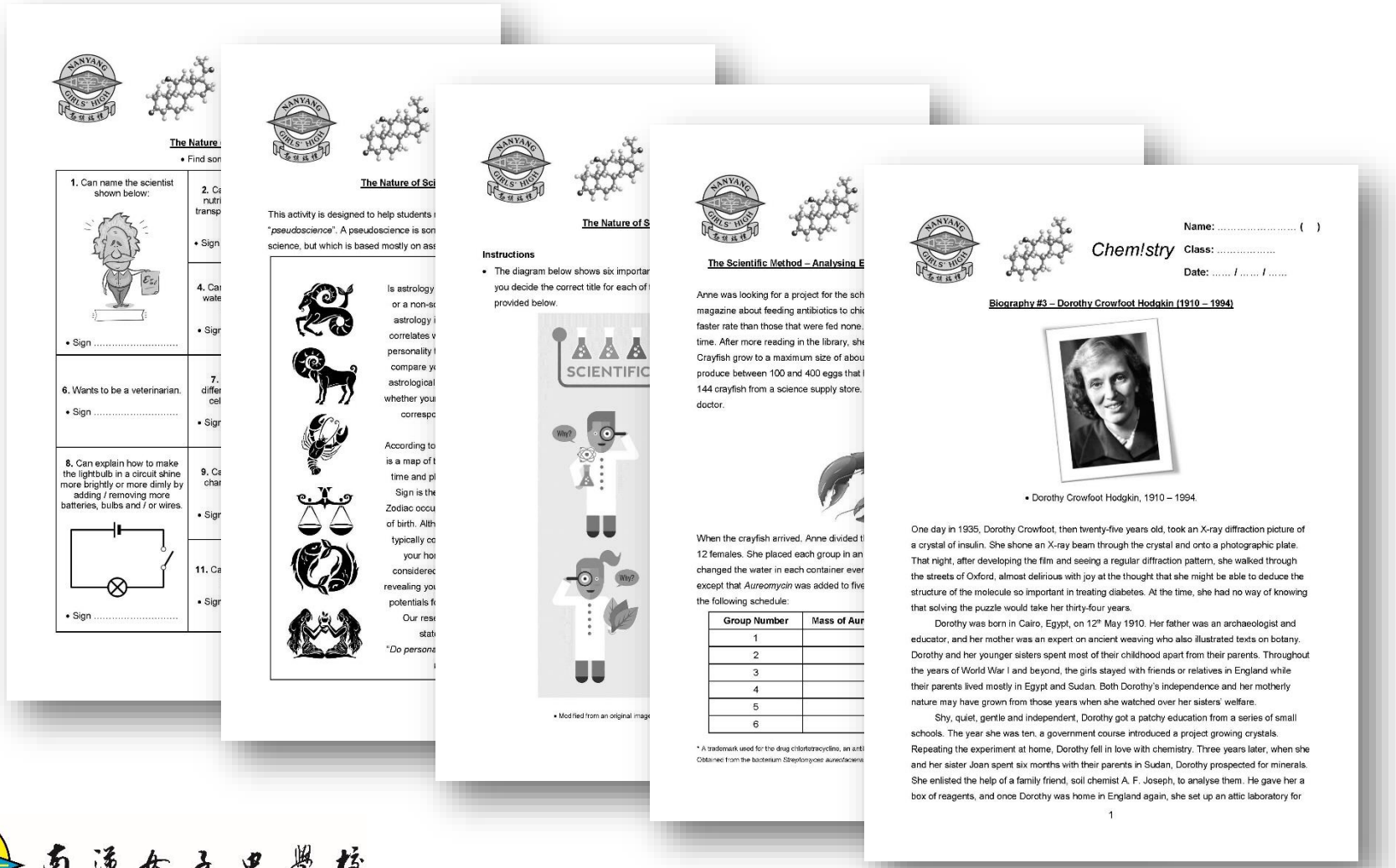
Implementing the Interdisciplinary Lessons

- The first two weeks (or thereabouts) of each subject were dedicated to understanding the nature of its core discipline.

- Students learned about the essential characteristics of the discipline as well as the qualities of experts in that field of human knowledge, *e.g.* how do they think and behave when trying to find the solution to a novel problem?

Implementing the Interdisciplinary Lessons

The Nature of Science



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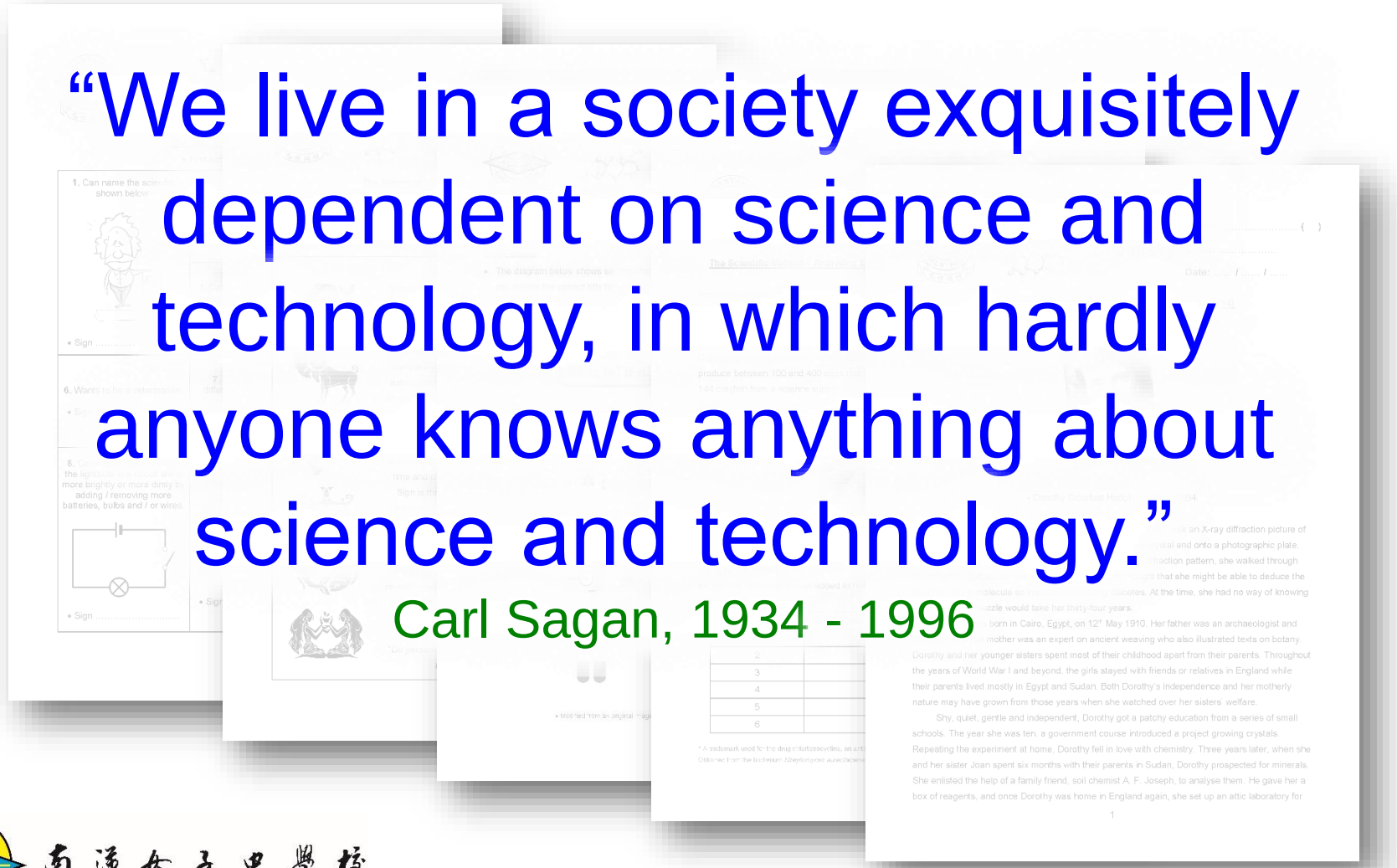
Implementing the Interdisciplinary Lessons

The Nature of Science



"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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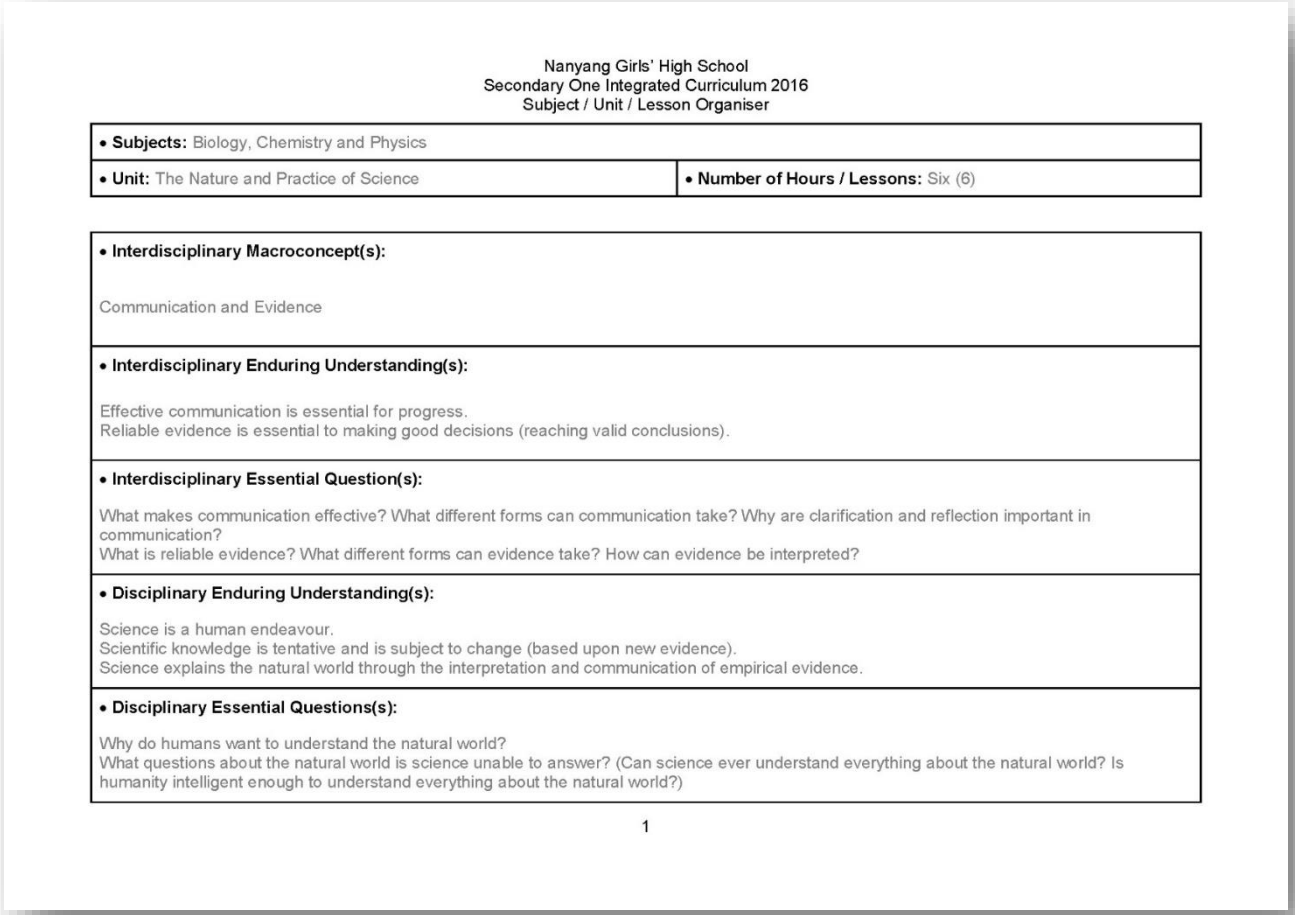
Implementing the Interdisciplinary Lessons



Nanyang Girls' High School
Secondary One Integrated Curriculum 2016
Subject / Unit / Lesson Organiser

• **Subjects:** Biology, Chemistry and Physics	
• **Unit:** The Nature and Practice of Science	• **Number of Hours / Lessons:** Six (6)

• **Interdisciplinary Macroconcept(s):**

Communication and Evidence

• **Interdisciplinary Enduring Understanding(s):**

Effective communication is essential for progress.
Reliable evidence is essential to making good decisions (reaching valid conclusions).

• **Interdisciplinary Essential Question(s):**

What makes communication effective? What different forms can communication take? Why are clarification and reflection important in communication?
What is reliable evidence? What different forms can evidence take? How can evidence be interpreted?

• **Disciplinary Enduring Understanding(s):**

Science is a human endeavour.
Scientific knowledge is tentative and is subject to change (based upon new evidence).
Science explains the natural world through the interpretation and communication of empirical evidence.

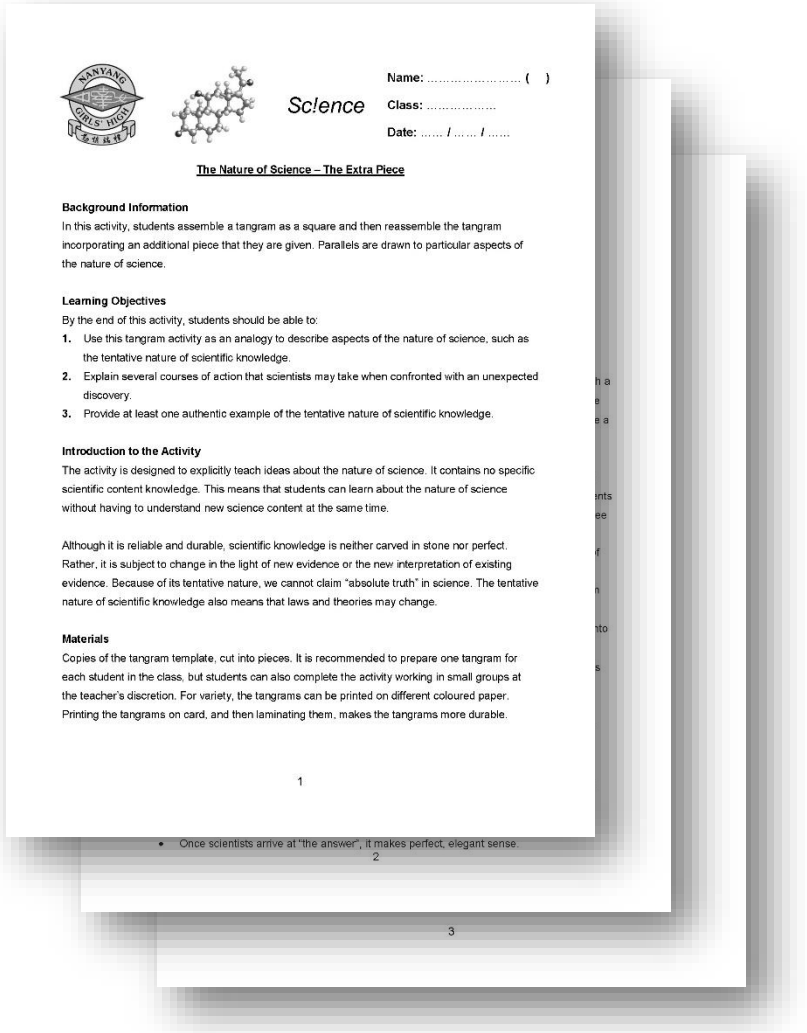
• **Disciplinary Essential Questions(s):**

Why do humans want to understand the natural world?
What questions about the natural world is science unable to answer? (Can science ever understand everything about the natural world? Is humanity intelligent enough to understand everything about the natural world?)

1

- Unit plan for the two week Nature of Science module.

Implementing the Interdisciplinary Lessons



Science

Name: ..... ( )
Class: .....
Date: ..... / ..... / .....

The Nature of Science – The Extra Piece

Background Information

In this activity, students assemble a tangram as a square and then reassemble the tangram incorporating an additional piece that they are given. Parallels are drawn to particular aspects of the nature of science.

Learning Objectives

By the end of this activity, students should be able to:

1. Use this tangram activity as an analogy to describe aspects of the nature of science, such as the tentative nature of scientific knowledge.
2. Explain several courses of action that scientists may take when confronted with an unexpected discovery.
3. Provide at least one authentic example of the tentative nature of scientific knowledge.

Introduction to the Activity

The activity is designed to explicitly teach ideas about the nature of science. It contains no specific scientific content knowledge. This means that students can learn about the nature of science without having to understand new science content at the same time.

Although it is reliable and durable, scientific knowledge is neither carved in stone nor perfect. Rather, it is subject to change in the light of new evidence or the new interpretation of existing evidence. Because of its tentative nature, we cannot claim "absolute truth" in science. The tentative nature of scientific knowledge also means that laws and theories may change.

Materials

Copies of the tangram template, cut into pieces. It is recommended to prepare one tangram for each student in the class, but students can also complete the activity working in small groups at the teacher's discretion. For variety, the tangrams can be printed on different coloured paper. Printing the tangrams on card, and then laminating them, makes the tangrams more durable.

1

- Once scientists arrive at "the answer", it makes perfect, elegant sense.

2

3

The Nature of Science:

- An example of a classroom activity.

1. You have been given four pieces of card. Each piece represents a piece of experimental data.

2. Arrange the four pieces of card into a square. This is your theory or hypothesis based upon the evidence that you have.

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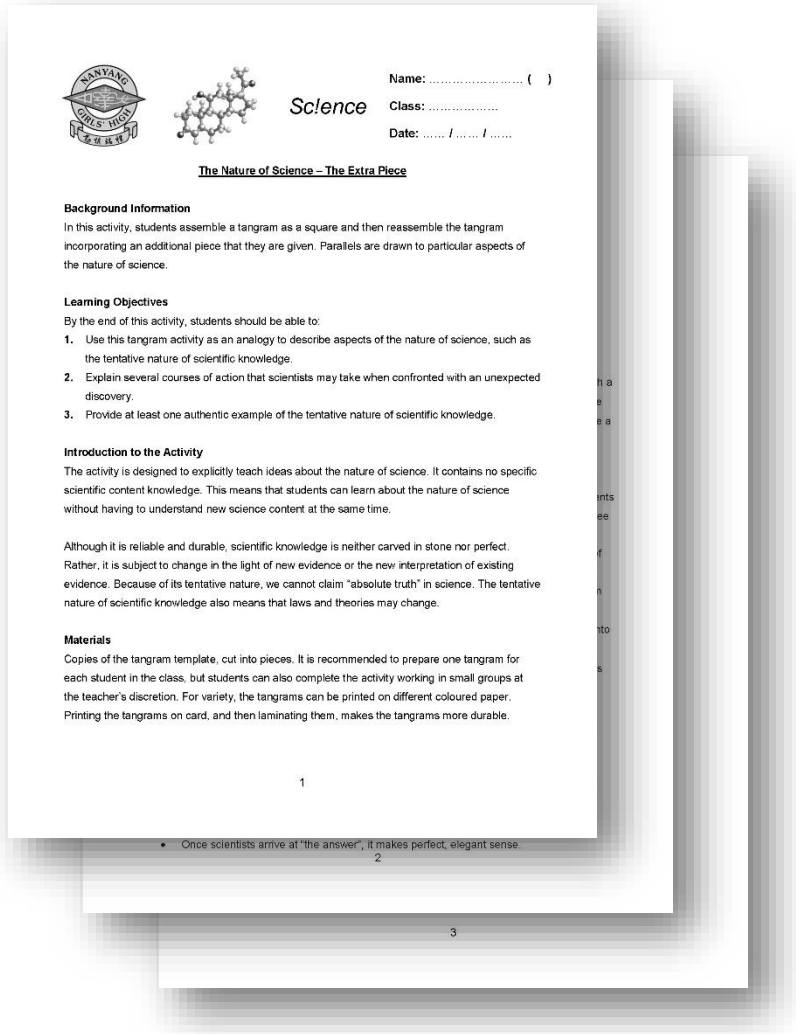
Implementing the Interdisciplinary Lessons



Science

Name: ..... ( )

Class: .....

Date: ..... / ..... / .....

The Nature of Science – The Extra Piece

Background Information

In this activity, students assemble a tangram as a square and then reassemble the tangram incorporating an additional piece that they are given. Parallels are drawn to particular aspects of the nature of science.

Learning Objectives

By the end of this activity, students should be able to:

1. Use this tangram activity as an analogy to describe aspects of the nature of science, such as the tentative nature of scientific knowledge.
2. Explain several courses of action that scientists may take when confronted with an unexpected discovery.
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1

- Once scientists arrive at "the answer", it makes perfect, elegant sense.

2

3

The Nature of Science:

- An example of a classroom activity.

3. You are now given a fifth piece of card. This is equivalent to a scientist discovering a new piece of data.

4. Arrange the five pieces of card into a square. Can the new piece of data be incorporated into the existing hypothesis, or is there a need for a new hypothesis?

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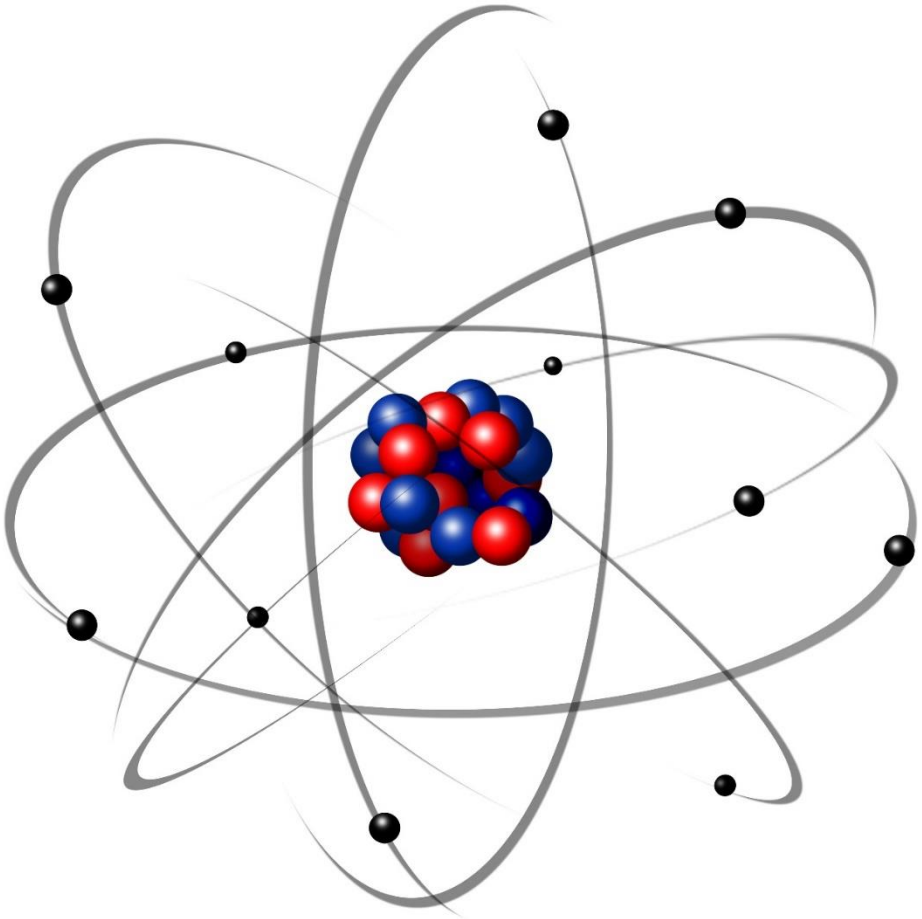
Implementing the Interdisciplinary Lessons

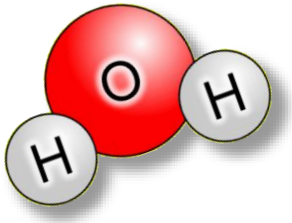


Implementing the Interdisciplinary Lessons

- The modern theory of atomic structure is a conceptual model based upon evidence.
- What are some generalisation about models and evidence?
- Which other subjects use evidence?
- How do we know that the evidence is reliable?

Implementing the Interdisciplinary Lessons

- Question: How many water molecules in a mouth full (18 cm^3) of water (H_2O)?



→ There are…

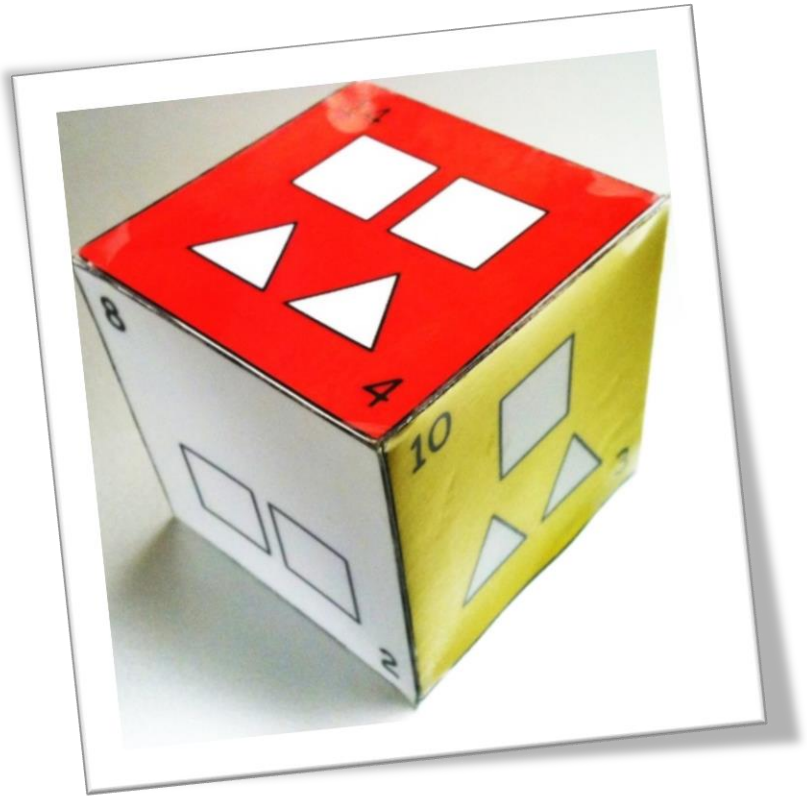
600 000 000 000 000 000 000 000

or 6×10^{23} molecules in 18 cm^3 of water

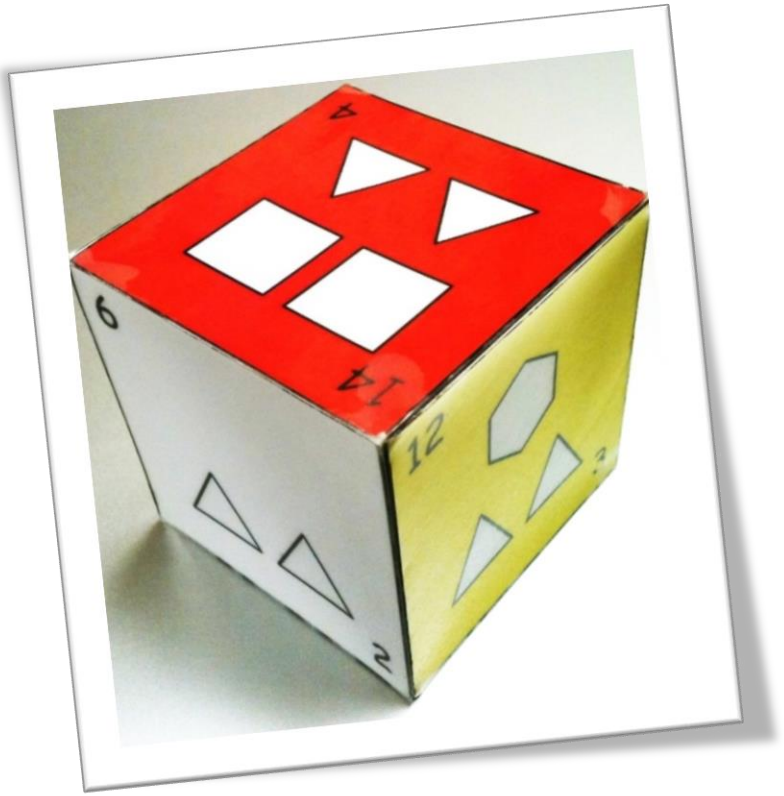
→ Water molecules, and the atoms that they are composed of, are very small!

→ Even with powerful instrumentation, the structure of the atom has never been seen, so how do we know what they look like?

Implementing the Interdisciplinary Lessons

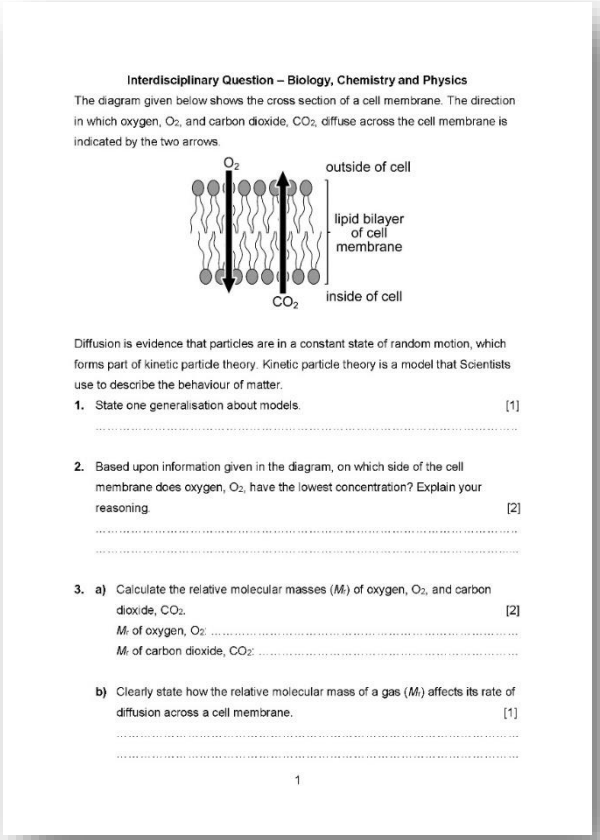


- A model to show how scientists make predictions about what cannot be observed.



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

Implementing the Interdisciplinary Lessons



Interdisciplinary Question – Biology, Chemistry and Physics

The diagram given below shows the cross section of a cell membrane. The direction in which oxygen, O_2, and carbon dioxide, CO_2, diffuse across the cell membrane is indicated by the two arrows.

Diffusion is evidence that particles are in a constant state of random motion, which forms part of kinetic particle theory. Kinetic particle theory is a model that Scientists use to describe the behaviour of matter.

1. State one generalisation about models. [1]

2. Based upon information given in the diagram, on which side of the cell membrane does oxygen, O_2, have the lowest concentration? Explain your reasoning. [2]

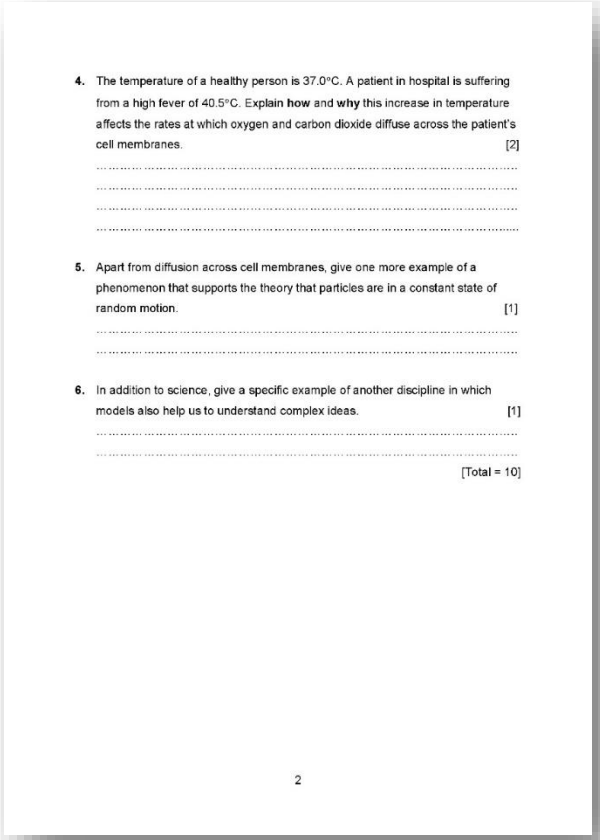
3. a) Calculate the relative molecular masses (M_r) of oxygen, O_2, and carbon dioxide, CO_2. [2]

   M_r of oxygen, O_2: .....

   M_r of carbon dioxide, CO_2: .....

   b) Clearly state how the relative molecular mass of a gas (M_r) affects its rate of diffusion across a cell membrane. [1]

1



4. The temperature of a healthy person is 37.0°C. A patient in hospital is suffering from a high fever of 40.5°C. Explain **how** and **why** this increase in temperature affects the rates at which oxygen and carbon dioxide diffuse across the patient's cell membranes. [2]

5. Apart from diffusion across cell membranes, give one more example of a phenomenon that supports the theory that particles are in a constant state of random motion. [1]

6. In addition to science, give a specific example of another discipline in which models also help us to understand complex ideas. [1]

[Total = 10]

2

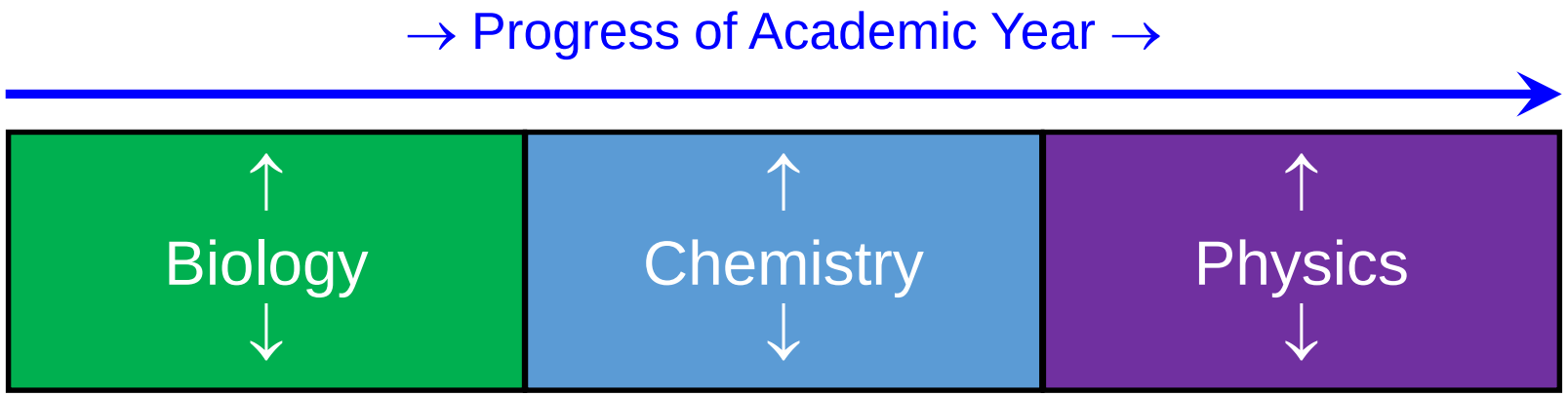
- Interdisciplinary question, worth 10 marks, on the Sec. 1 end-of-year exam 2016.

Implementing the Interdisciplinary Lessons

- Questions posed by S1-11, NYGH, January 2016.

Implementing the Interdisciplinary Lessons

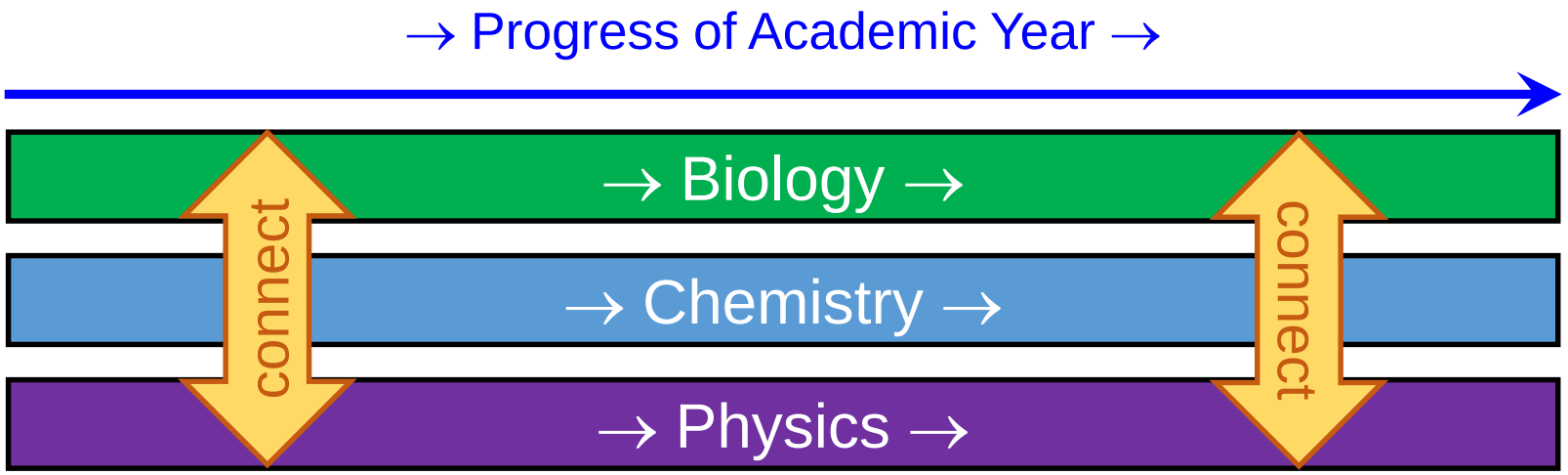
- Instead of following a typical Lower Secondary Science modular curriculum, each one of the three sciences ran concurrently throughout the entire school year. Students had one hour of Biology, one hour of Chemistry and one hour of Physics each week.



- Typical Modular Lower Secondary Science Curriculum

Implementing the Interdisciplinary Lessons

- The “linear” curriculum allowed for connections to be made between the three sciences throughout the academic year – something that would not have been possible with a typical modular curriculum.



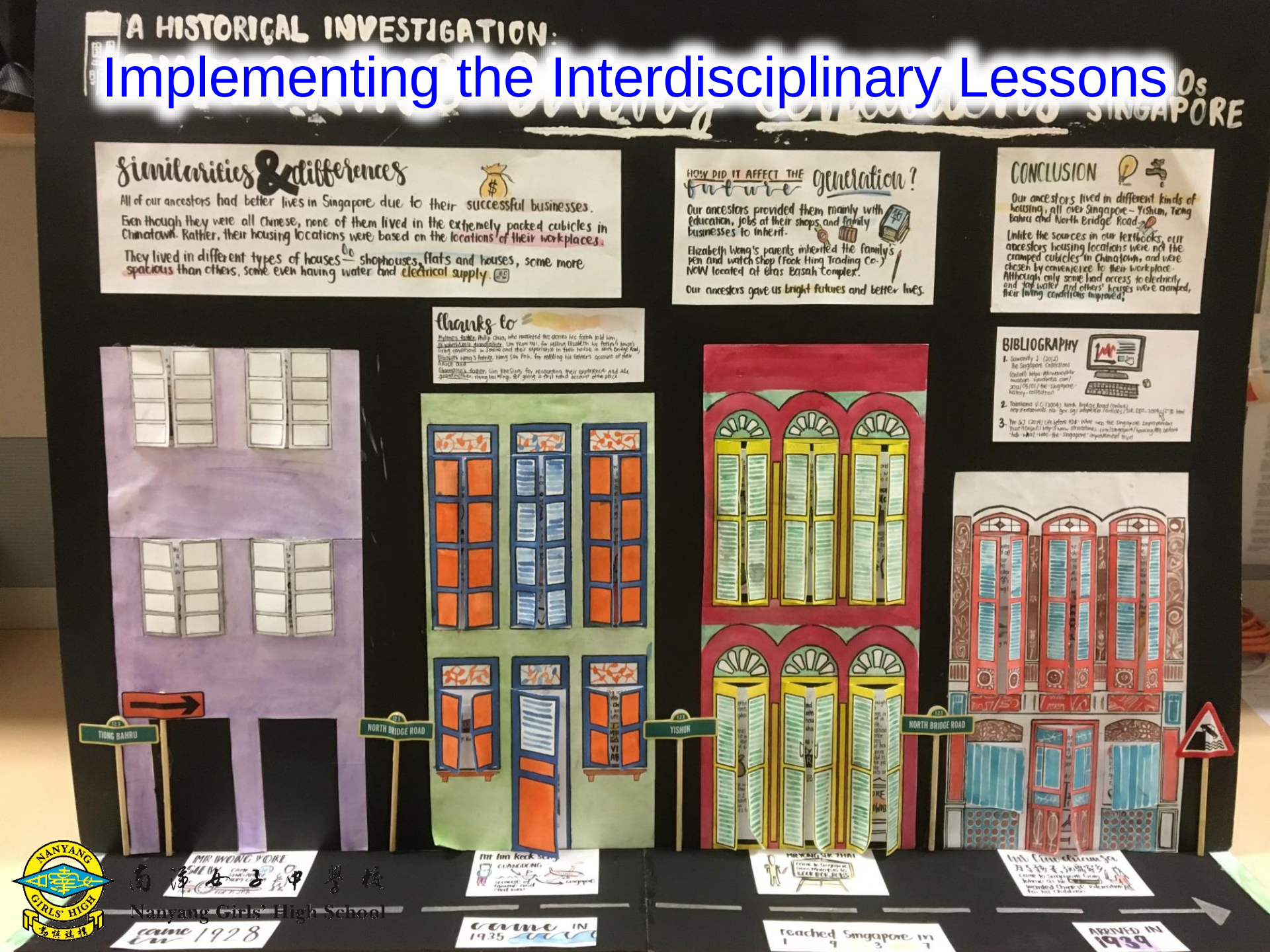
- New Linear Lower Secondary Science Curriculum

Implementing the Interdisciplinary Lessons

- There were concerns that this linear science curriculum may overload the students, but only one class mentioned it – as an observation, not a criticism – within the first term.

- In the long term, a linear science curriculum at Sec. 1 and Sec. 2 may reduce stress on the students during their transition from Sec. 2 to Sec. 3. This is because one of the main causes of stress amongst the Sec. 3 students (as reported by the students themselves) is getting use to studying eight or nine different subjects at the same time – something that they will already be familiar with following the lower secondary interdisciplinary curriculum.

Implementing the Interdisciplinary Lessons



Nanyang Girls' High School

Implementing the Interdisciplinary Units

Chapter Four:

How were the interdisciplinary units implemented by the teachers?

Implementing the Interdisciplinary Units

Scenario for the Interdisciplinary Units:

- The year is 2036. Nanyang Girls' High School is the first school to be awarded the Urban Redevelopment Authority's sustainable living award.
- As the winner of this award, the school has to organise an exposition to communicate its winning ideas to the general public.
- Your group (4 – 5 students) has been selected to present its winning project at the exposition.
- Use the past and present to predict the future.

Implementing the Interdisciplinary Units

- Both of the Interdisciplinary Units, Garden to Table and The Build Environment, were assessed together.

- Students had to have the following as their product(s):

→ Oral presentation (English and Mandarin).

and at least ~~one~~ two others…

→ Poster.
→ Model.
→ Photo journal.
→ Short film.
→ Other possible options…

Implementing the Interdisciplinary Units

- Three key rubrics were used for grading:

→ Process (ideation, execution, reflection).
→ Product (e.g. model).
→ Presentation.

- Grading of the *process* was continuous. The final grade was awarded in Week 7 of the Interdisciplinary Unit (Term 3 Week 4) by the group's mentor.

- The *product* was graded at the exposition in the school hall. Three assessors graded 4 – 6 groups of students.

- The *presentation* was graded on both occasions mentioned above.

Implementing the Interdisciplinary Units

- Students had to think critically and creatively and make valid assumptions based upon what they had learnt during the Interdisciplinary Unit in order to visualise and rationalise Nanyang Girls High School as a model of sustainability in 2036. Students were encouraged to infuse the 16 Habits of Mind into their work.

- Projects had to clearly demonstrate sustainability and had to be mindful of Nanyang Girls' High School's environment, culture, heritage and local neighbourhood.

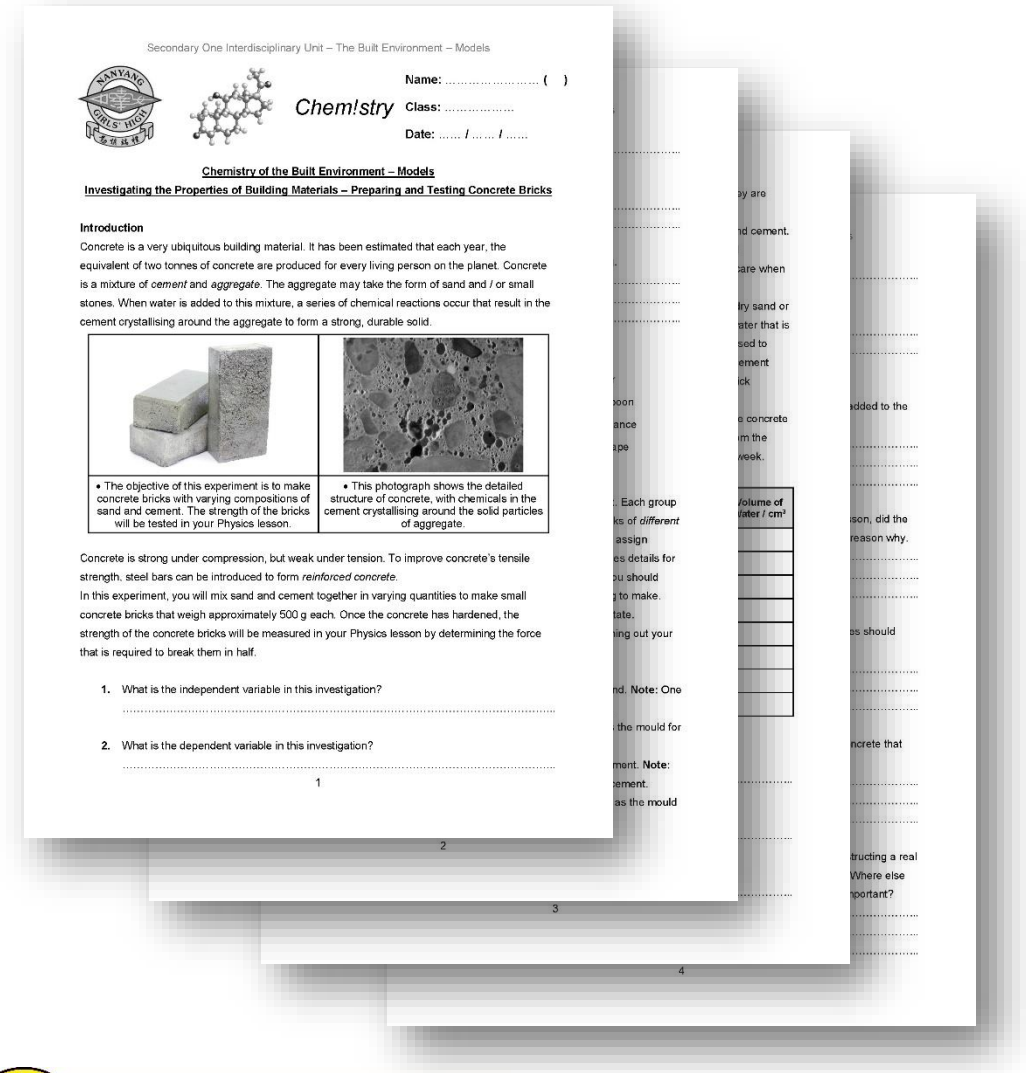
Implementing the Interdisciplinary Units

- Estimated that the students have a total curriculum time of 21 hours per week.

- Over 6 weeks, this equals a total of 126 hours to be shared between the various subjects.

- "White Space" was also needed for the students to do their project work, to meet with their mentors and also for learning journeys and presentations by guest speakers.

Implementing the Interdisciplinary Units



Secondary One Interdisciplinary Unit – The Built Environment – Models

Chem!stry

Name: ..... ( )

Class: .....

Date: ..... / ..... / .....

Chemistry of the Built Environment – Models

Investigating the Properties of Building Materials – Preparing and Testing Concrete Bricks

Introduction

Concrete is a very ubiquitous building material. It has been estimated that each year, the equivalent of two tonnes of concrete are produced for every living person on the planet. Concrete is a mixture of *cement* and *aggregate*. The aggregate may take the form of sand and / or small stones. When water is added to this mixture, a series of chemical reactions occur that result in the cement crystallising around the aggregate to form a strong, durable solid.

• The objective of this experiment is to make concrete bricks with varying compositions of sand and cement. The strength of the bricks will be tested in your Physics lesson.	• This photograph shows the detailed structure of concrete, with chemicals in the cement crystallising around the solid particles of aggregate.

Concrete is strong under compression, but weak under tension. To improve concrete's tensile strength, steel bars can be introduced to form *reinforced concrete*.

In this experiment, you will mix sand and cement together in varying quantities to make small concrete bricks that weigh approximately 500 g each. Once the concrete has hardened, the strength of the concrete bricks will be measured in your Physics lesson by determining the force that is required to break them in half.

1. What is the independent variable in this investigation?

.....

2. What is the dependent variable in this investigation?

.....

1

2

3

4

Science of the Built Environment

- In their Chemistry lessons, students made concrete bricks changing the mass of sand and cement (independent variables).

- In their Physics lessons, students determined the force required to break each of the bricks (dependent variable).

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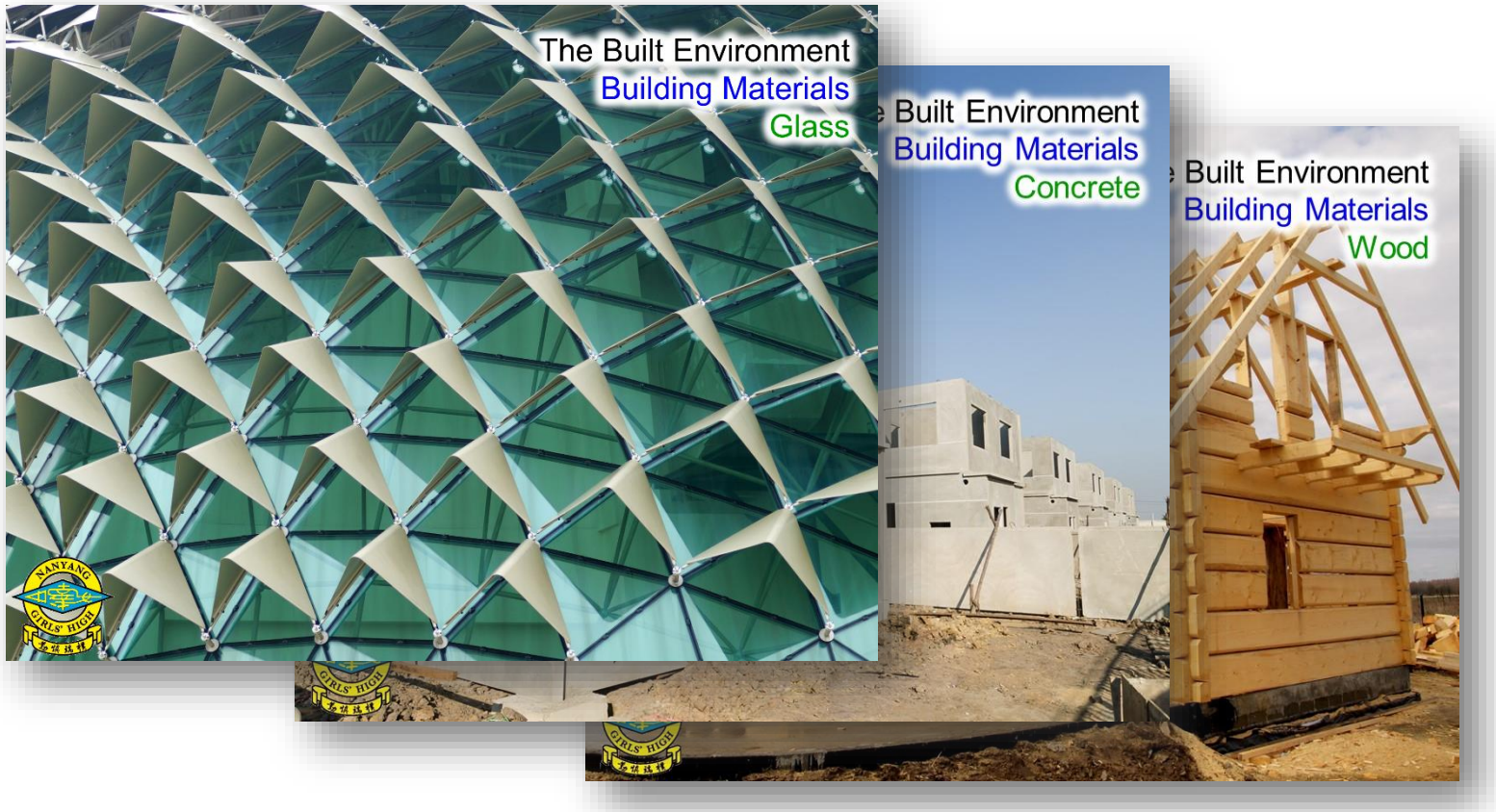
Implementing the Interdisciplinary Units



- Chemistry of the built environment considered different building materials – their advantages, disadvantages and impact on the environment.

Implementing the Interdisciplinary Units

Implementing the Interdisciplinary Units

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Implementing the Interdisciplinary Units

Term Two
Week Nine
Experiential Learning Journeys

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Implementing the Interdisciplinary Units

During the Learning Journeys…

- Students look, think and ask questions.
- Students record their learning experience in a photo journal, video, animation, comic strip, sketches, mind-map.

By the end of the Learning Journeys…

- Students should understand how Singapore uses its limited land space…

→ To build for shelter, and other applications.

→ To grow / provide food for our survival.

- Students should be able to design…

→ A sustainable place to live and work.

→ A garden for the future.

Implementing the Interdisciplinary Units

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Implementing the Interdisciplinary Units

Implementing the Interdisciplinary Units

Implementing the Interdisciplinary Units

Ex·po·si·tion
[ek-sp*uh*-**zish**-*uh*-n]

Noun

1. A large-scale public exhibition or show, as of art or manufactured products.

2. The art of expounding, setting forth or explaining.

3. The art of presenting to view; display.

Implementing the Interdisciplinary Units

- The three hour exposition took place in the school hall on the final day of the Interdisciplinary Units.

- Each group of students were given two desks and display boards to help facilitate their presentation. Some groups also used iPads to show photographs and videos.

- The students' work was evaluated by ten groups of three assessors – two teachers and one external invited guest. Each group of assessors evaluated the students based upon their ability to; a) rationalise the idea of a sustainable community, b) make connections between disciplines, c) offer possible solutions (which may or may not be completely feasible) to authentic problems.

Implementing the Interdisciplinary Units

Rubric for Product

	Level of Achievement				
	Master **15 / 14 / 13**	**Expert** **12 / 11 / 10**	**Competent** **9 / 8 / 7**	**Developing** **6 / 5 / 4**	**Unobserved** **3 / 2/ 1**
ARTICULATION OF IDEAS	❑ Highly relevant and consistent exploration and development with [illegible]	❑ Relevant and consistent exploration and development of [illegible]	❑ Some exploration and development of ideas which are relevant to task.	❑ Limited exploration and development of [illegible]	❑ Little or no evidence of exploration and development of [illegible]
CREATIVITY / IMAGINATION	❑ Highly feasible product which is new, unique and successfully breaks rules and conventions. ❑ Extensive use of [illegible] unconventional ways.	❑ Product which is new, unique and successfully breaks rules and conventions. ❑ Adequate attempt to step outside rules and [illegible] for common materials or ideas.	❑ Some new ideas or improvements, but product is predictable or conventional. ❑ Some attempt to step outside rules and conventions [illegible] materials or ideas.	❑ Product which relies on existing models and is not new nor unique ❑ Uses materials and ideas in typical ways.	❑ Product appears incoherent with design intent. ❑ Uses materials and ideas in inappropriate ways.
DESIGN	❑ Use of colours, lines, textures, contrast and emphasis in the product is highly relevant to design intent, effective and eye-catching.	❑ Use of colours, lines, textures, contrast and emphasis in the product is relevant to design intent.	❑ Use of colours, lines, textures, contrast and emphasis in the [illegible] relevant to design intent.	❑ Use of colours, lines, textures, contrast and emphasis in the product have little relevance to design intent of the product.	❑ Little or no evidence of understanding of colours, lines, textures, contrast and emphasis in the product.

Articulation of Ideas

Creativity / Imagination

Design

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Implementing the Interdisciplinary Units

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Implementing the Interdisciplinary Units

Exerts from the online learning community…

Class S1-07 – IDU Group Six

Class S1-03 – IDU Group Four

Class S1-12 – IDU Group Two

Class S1-11 – IDU Group One

Class S1-03 – IDU Group One

Conclusions on the Interdisciplinary Curriculum

Chapter Five:

On reflection, what has been learnt about the new Secondary One interdisciplinary curriculum at Nanyang Girls' High School 2016?

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Conclusions on the Interdisciplinary Curriculum

- It is important to have a team of teachers who see value in the new curriculum.
- Teachers need to step out of their comfort-zones and take responsible risks.
- Teachers need to take a creative approach to the ways in which they design their units / lessons.
- Teachers need to be adaptable, flexible, open-minded and receptive to new ideas.
- Teachers need to communicate within and across disciplines.

Conclusions on the Interdisciplinary Curriculum

- Some of the students reported feeling uncomfortable with the ambiguity and open-ended nature of the Interdisciplinary Units – citing the stress of group-work, oral presentations and preparation for the final exposition as examples.

- Not surprisingly – coming from a Primary 6 background that prepared them for the Primary School Leaving Examination – a number of students said that they would have preferred to have studied to a Sec. 1 mid-year examination instead of completing the Interdisciplinary Units.

Conclusions on the Interdisciplinary Curriculum

- Because the Interdisciplinary Units ran both before and after the June holiday, some students reported that they felt obliged to meet and discuss school work with their peers during the vacation period.

- Students reported feeling initially uncomfortable with the style of the Interdisciplinary Units, but they missed the IDUs once they had finished and the students had to return to their “normal” classroom way of learning.

- The timetable was organised according to the needs of each individual subject. This led to an oversubscription of curriculum time that left very few hours in the week for the students to meet with their mentors.

Conclusions on the Interdisciplinary Curriculum

- Because Biology, Chemistry and Physics ran concurrently, teachers of the individual sciences only saw their classes for one hour each week. As a consequence, it took longer than usual (*i.e.* compared to a typical modular curriculum) for the teachers to “get-to-know” their students. A possible solution is for one teacher to teach all three sciences to a single class.

- Another issue with only seeing a class once a week were the occasional missed lessons due to national holidays and so on. As a consequence, the teacher would not see their class for two weeks.

Conclusions on the Interdisciplinary Curriculum

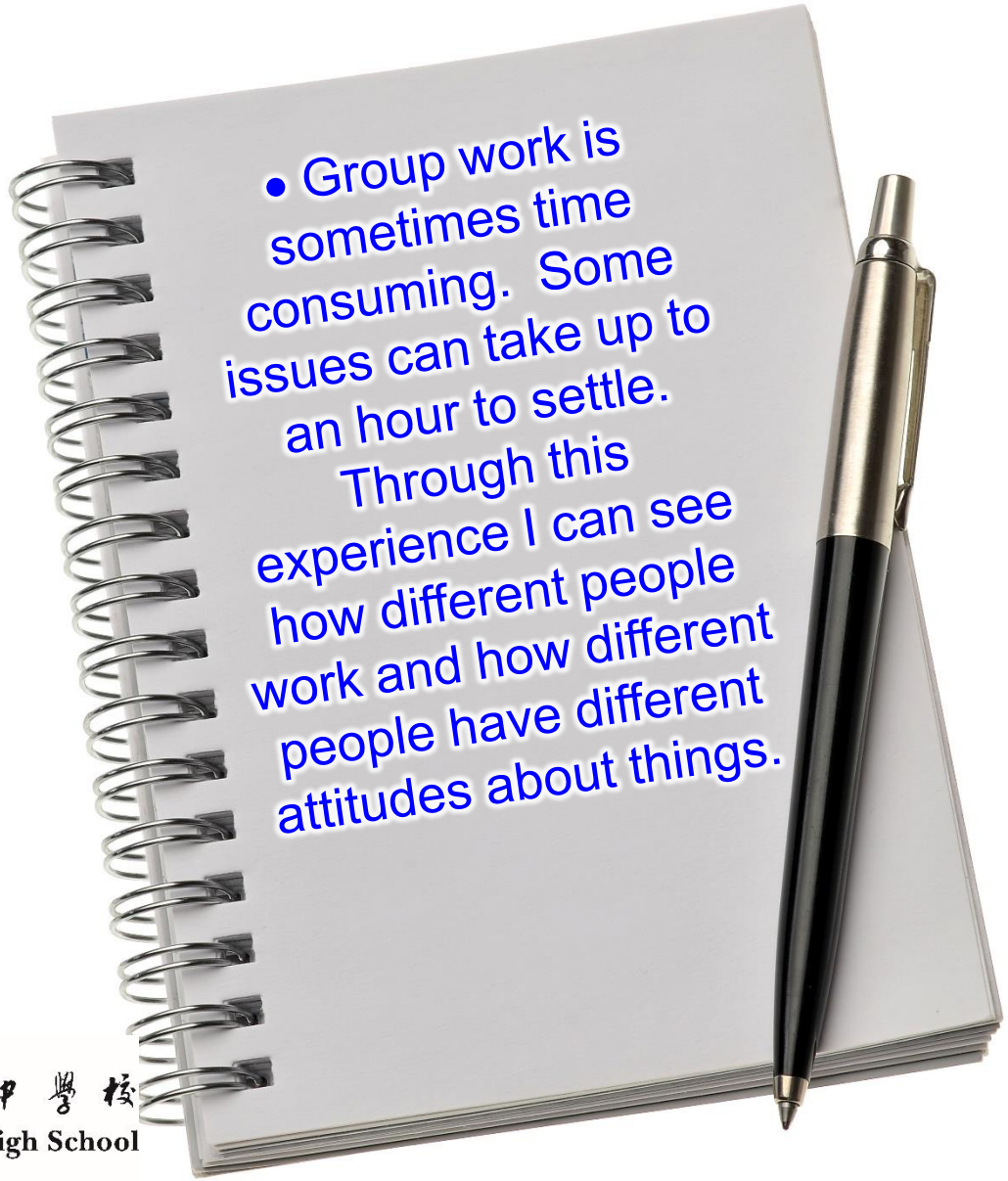
- "IDU stretches our thinking across other subjects."

- "I learnt about angle properties and how it applies to buildings."

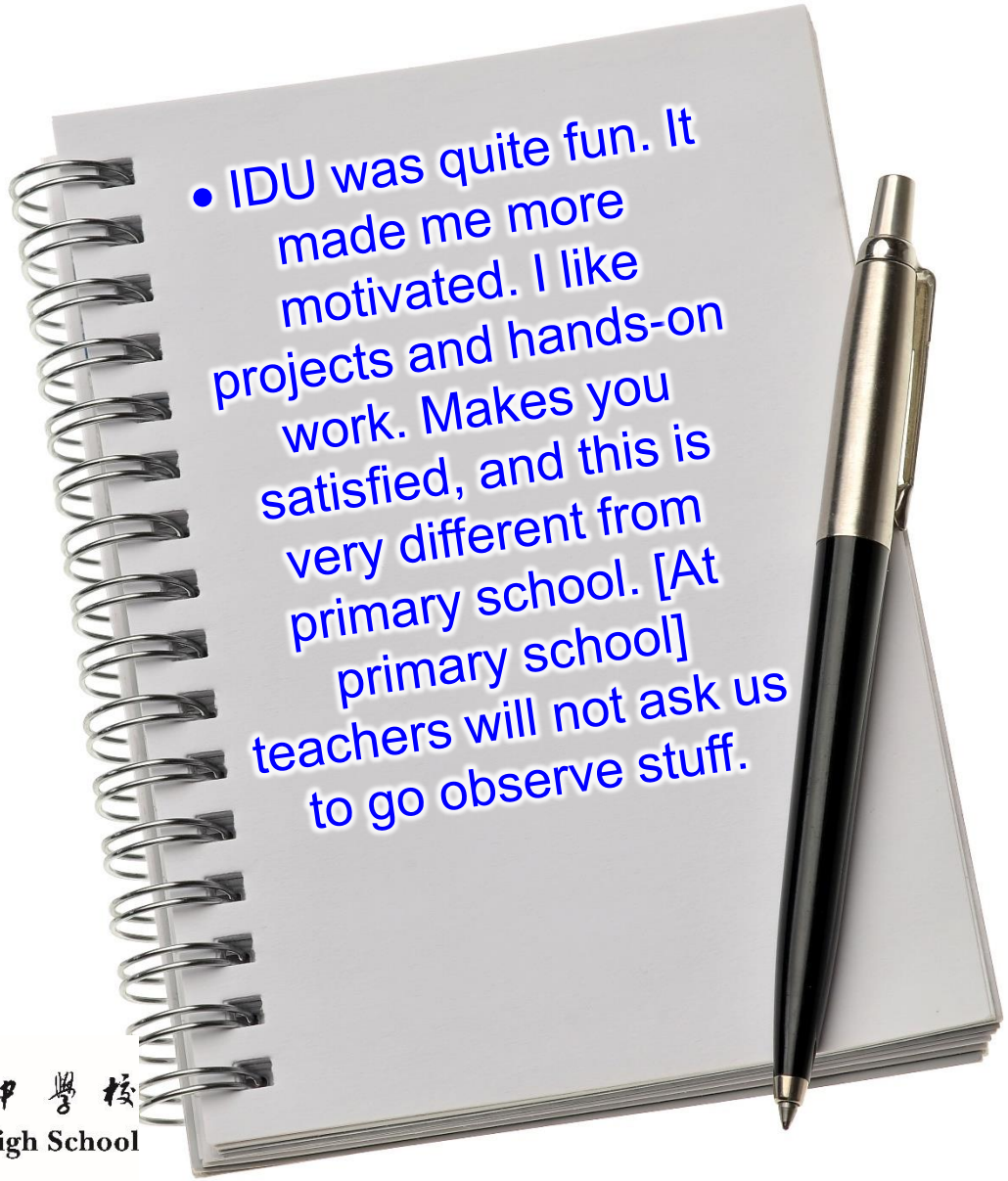
- "We learn to cite sources beyond what we learn in the subject."

- "We have to be more confident and get out of our comfort zone."

Conclusions on the Interdisciplinary Curriculum



Conclusions on the Interdisciplinary Curriculum

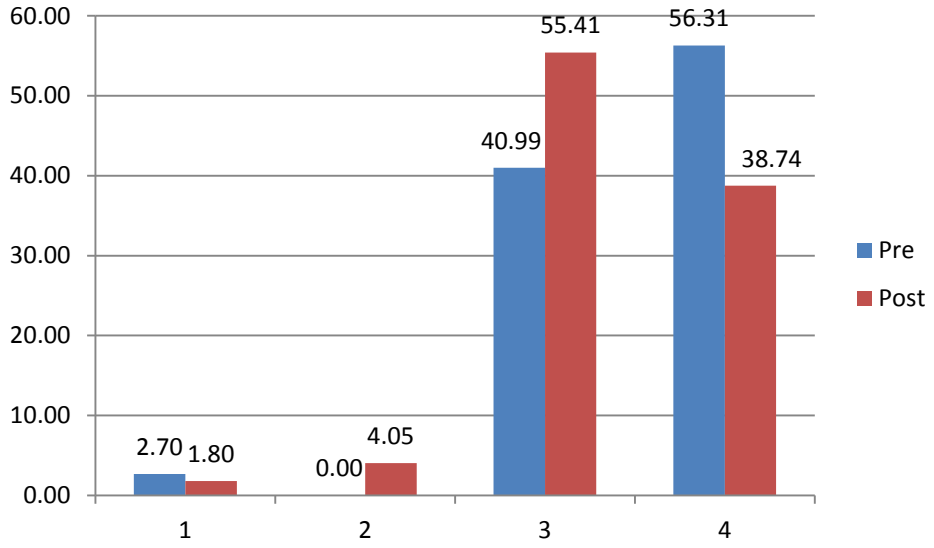


Conclusions on the Interdisciplinary Curriculum

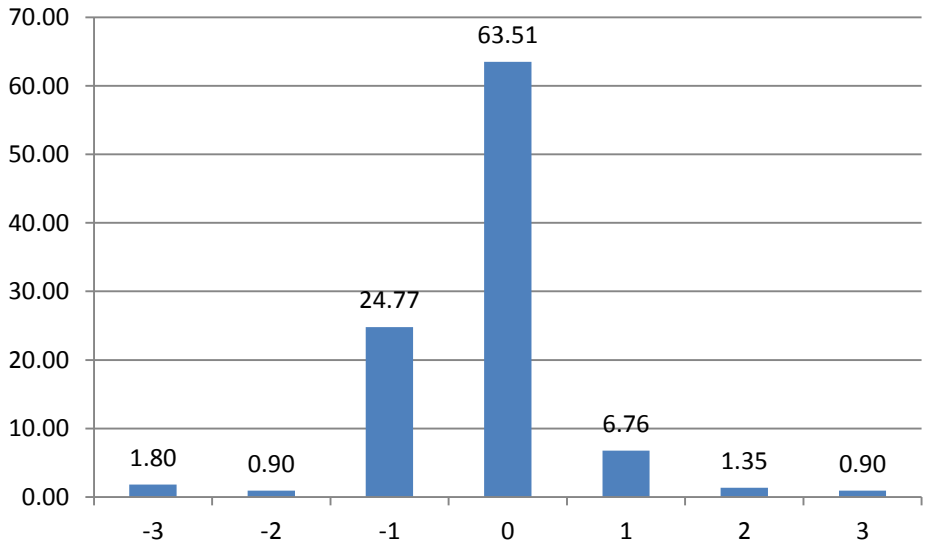
Q2. I appreciate that every member of the group has their own unique strengths.

Pre-Post

1 = Strongly Disagree, 4 = Strongly Agree



Pre-Post Shift

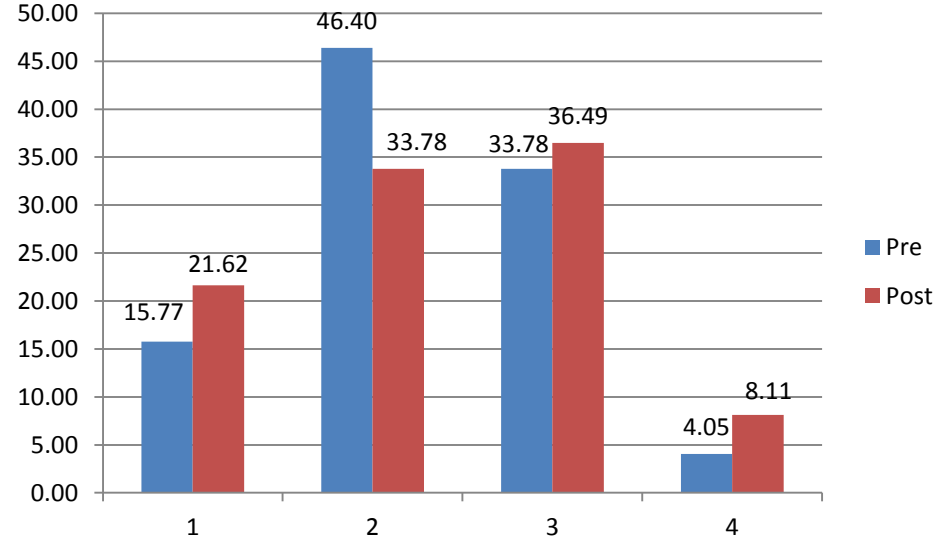


Conclusions on the Interdisciplinary Curriculum

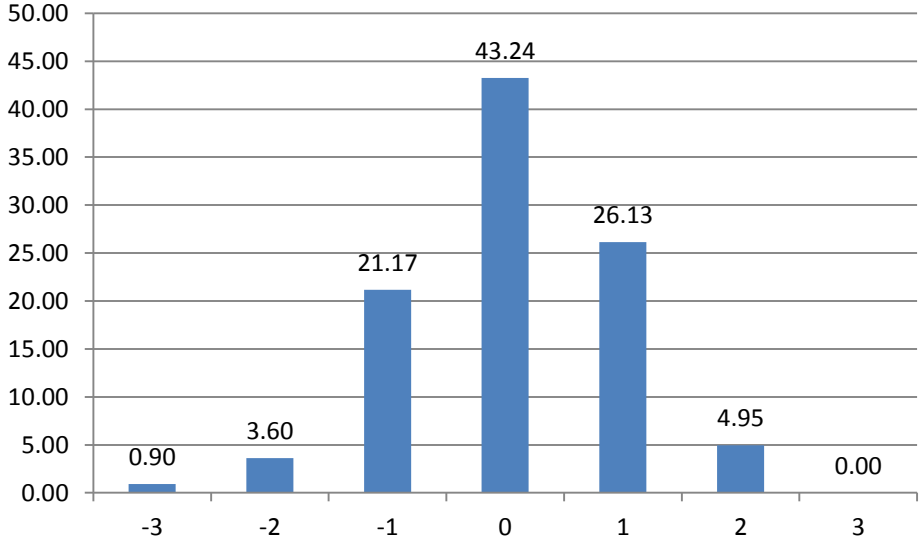
Q22. Within my group, work does not always have to be fairly distributed.

Pre-Post

1 = Strongly Disagree, 4 = Strongly Agree



Pre-Post Shift



Conclusions on the Interdisciplinary Curriculum

"Would you tell me, please, which way I ought to go from here?"

"That depends a good deal on where you want to get to," said the Cat.

"I don't much care where–" said Alice.

"Then it doesn't matter which way you go," said the Cat.

"–so long as I get SOMEWHERE," Alice added as an explanation.

"Oh, you're sure to do that," said the Cat, "if you only walk for long enough."

Alice's Adventures in Wonderland – Chapter 6

Thank you for your attention.
What questions do you have?

christopher_john_slatter@nygh.edu.sg

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