APEC Project InMside:

Inclusive Mathematics for Sustainability in a Digital Economy

Presentation on

Computational Thinking and Statistical Thinking in the Curriculum of Singapore

May 2019, Vina del Mar, Chile

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Outline

- Singapore Education System
- Computing Curriculum in Singapore
  - Computational Thinking in the Curriculum
  - Issues and Challenges
  - Examples of Teaching Materials for Computational Thinking
- Mathematics Education in Singapore
- Statistics Curriculum in Singapore
  - Overview
  - Developing statistical thinking
  - Challenges

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Singapore Education System

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Key Facts and Figures

About
430,000 students

Over
350 schools

for primary, secondary and post-secondary education supported by

About
33,000
education officers

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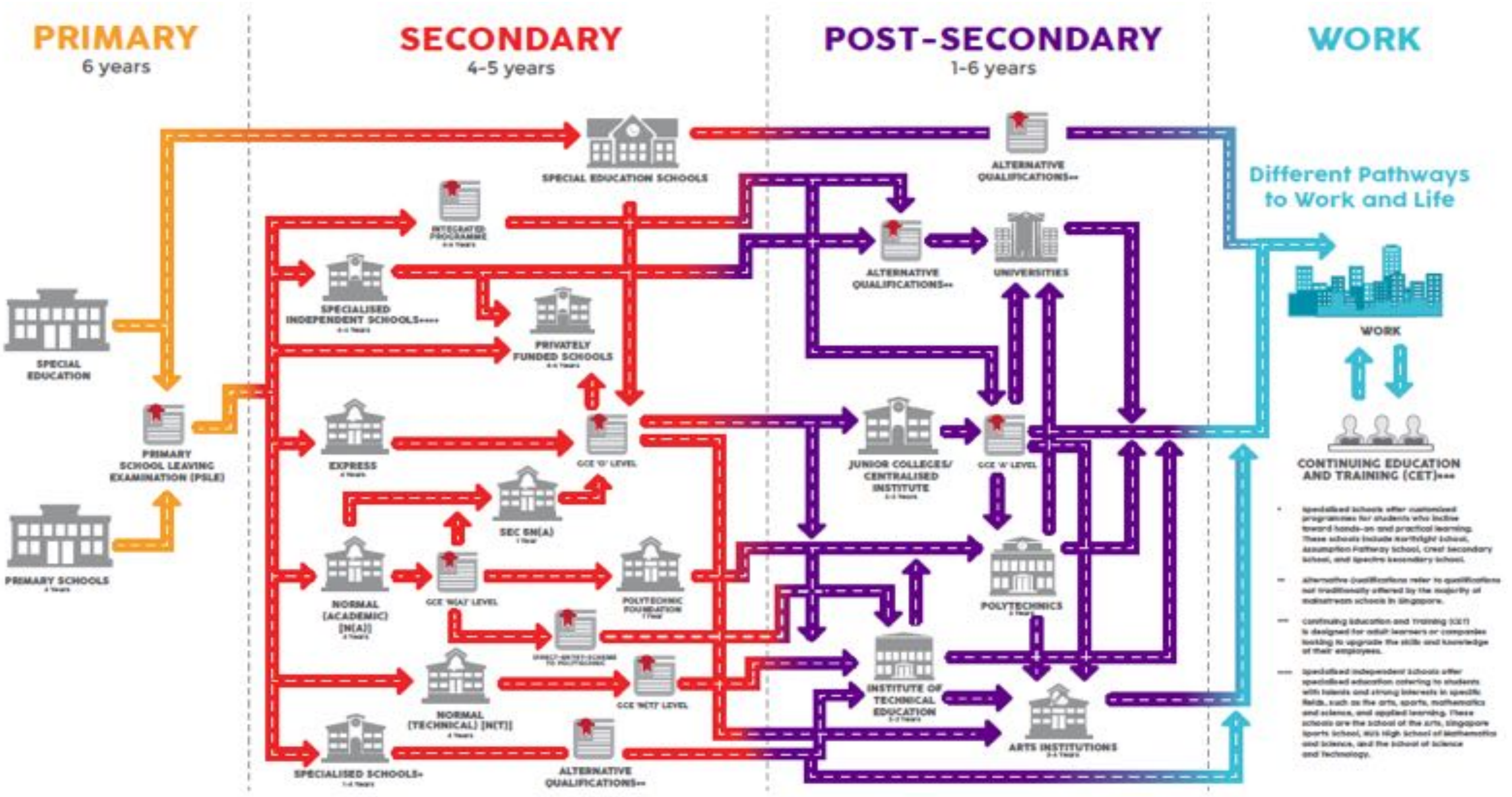
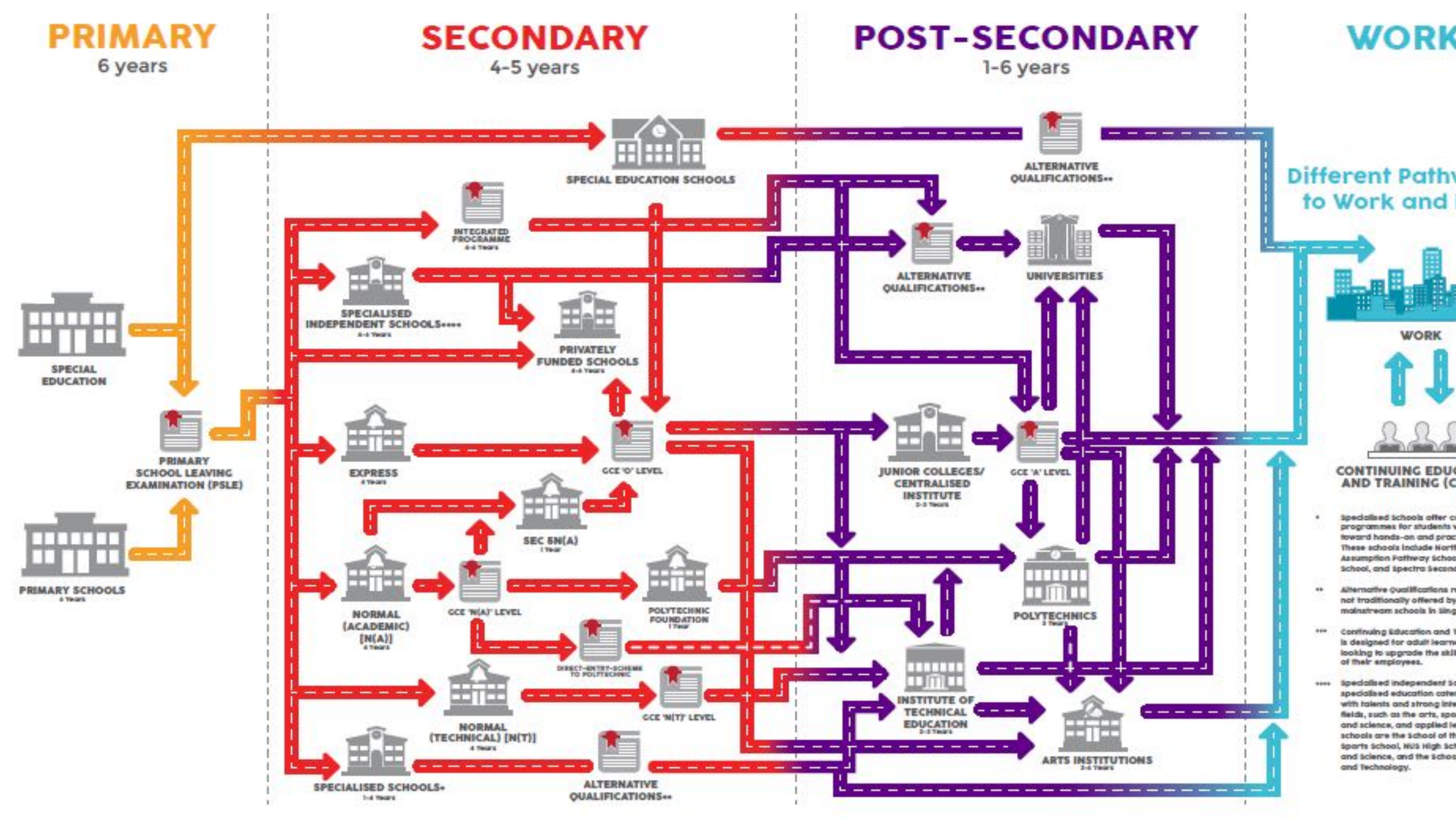
The Singapore Education Landscape




PRIMARY
6 years
SECONDARY
4-5 years
POST-SECONDARY
1-6 years
WORK
SPECIAL EDUCATION SCHOOLS
ALTERNATIVE QUALIFICATIONS**
INTEGRATED PROGRAMME
SPECIAL EDUCATION
SPECIALISED INDEPENDENT SCHOOLS****
PRIVATELY FUNDED SCHOOLS
ALTERNATIVE QUALIFICATIONS**
UNIVERSITIES
PRIMARY SCHOOL LEAVING EXAMINATION (PSLE)
EXPRESS
GCE 'O' LEVEL
JUNIOR COLLEGES/ CENTRALISED INSTITUTE
GCE 'A' LEVEL
SEC 5N(A)
PRIMARY SCHOOLS
NORMAL (ACADEMIC) [N(A)]
GCE 'N(A)' LEVEL
POLYTECHNIC FOUNDATION
POLYTECHNICS
DIRECT-ENTRY-SCHEME TO POLYTECHNIC
INSTITUTE OF TECHNICAL EDUCATION
GCE 'N(T)' LEVEL
NORMAL (TECHNICAL) [N(T)]
ARTS INSTITUTIONS
SPECIALISED SCHOOLS*
ALTERNATIVE QUALIFICATIONS**
Different Pathw
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* Specialised Schools offer c
programmes for students w
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** Alternative Qualifications n
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of their employees.
**** Specialised Independent Sc
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fields, such as the arts, spo
and science, and applied le
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Sports School, NUS High Sch
and Science, and the Schoo
and Technology.

Computing Curriculum

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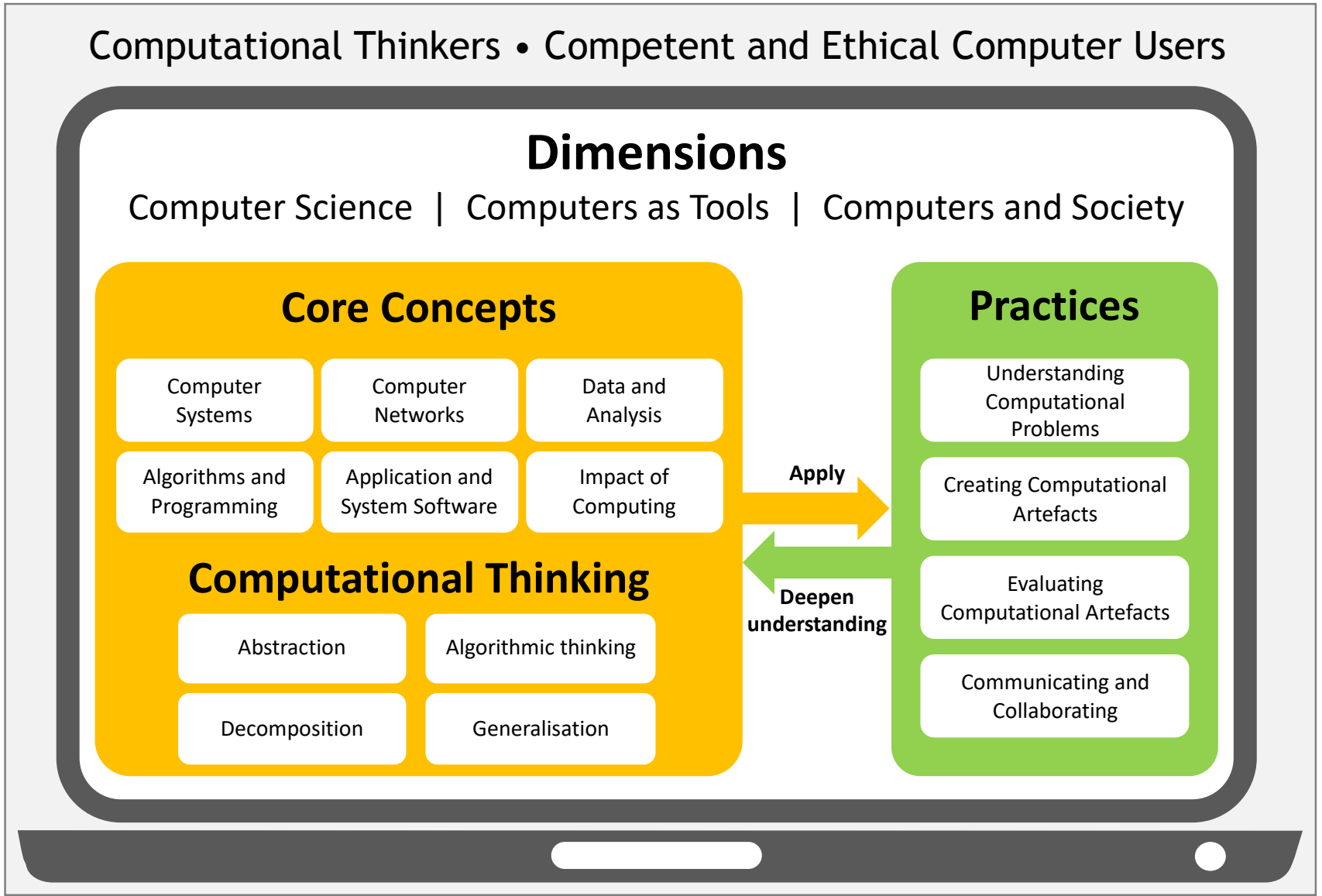
Computing Curriculum Framework



Computing Subjects

Secondary

N(T) Level Computer Applications

- Computer Fundamentals
- Media Elements
- Document Processing
- Spreadsheets
- Multimedia Communication
- Media Computing (Scratch)

O Level Computing

- Data and Information
- Systems and Communications
- Abstraction and Algorithms
- Programming (Python)

Pre-University

A Level Computing

- Algorithms and Data Structures
- Programming (Python)
- Data and Information
- Computer Networks

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Computational Thinking

In the Curriculum

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Points Under Pillar 1 (Traditional programming)

- All the computing subjects include programming (using either a visual- or text-based system).
- Computational thinking is more than programming, although it is a direct way to develop computational thinking.
- Coding enrichment programmes which involve programming robots or microcontrollers are also available to primary and secondary schools.

Point Under Pillar 2 (Modelling)

- The mathematics curriculum involves students in the building and interpretation of models through abstraction and generalisation.

- Students offering Computing subjects also learn and use modelling, e.g. identifying the inputs and outputs of a problem and representing its state using variables.

Points Under Pillar 3 (Machine Learning and Data Science)

- The mathematics curriculum provides a foundation in fundamental statistics, data analysis and probability that is necessary to access higher-level material.

- The computing curriculum covers ethical concerns as well as the social and economic impact of computers (including examples on the use of Artificial Intelligence).

- There are plans to introduce simple (non-technical) ideas of AI (e.g., use of training data) as part of a coding enrichment programme.

Issues and Challenges

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Issues and Challenges

- Teacher availability
- Limited curriculum time
- Infusion of Computational Thinking into non-computing subjects

Examples of Teaching Materials for Computational Thinking

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Students are introduced to algorithms through the familiar context of addition.

Step 1: Write the two input numbers such that digits in the ones place are aligned vertically.

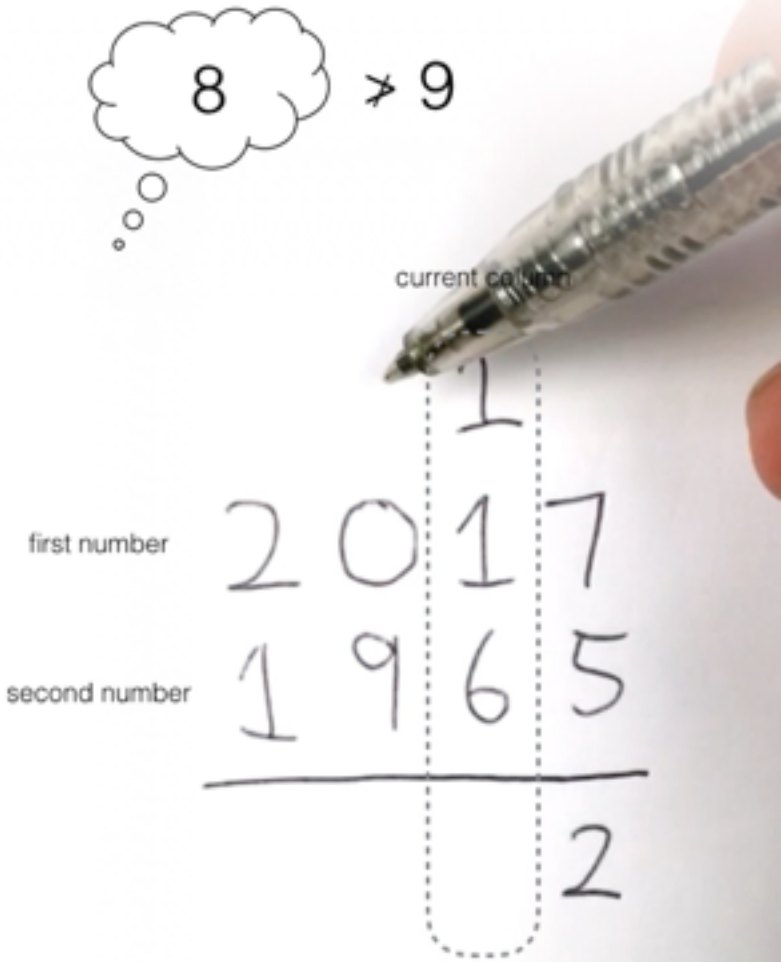
Step 2: Let the current column be the right-most column of digits.

Step 3: Add all digits in the current column.

Step 4: If the result is greater than 9, write a "carry-over" digit.

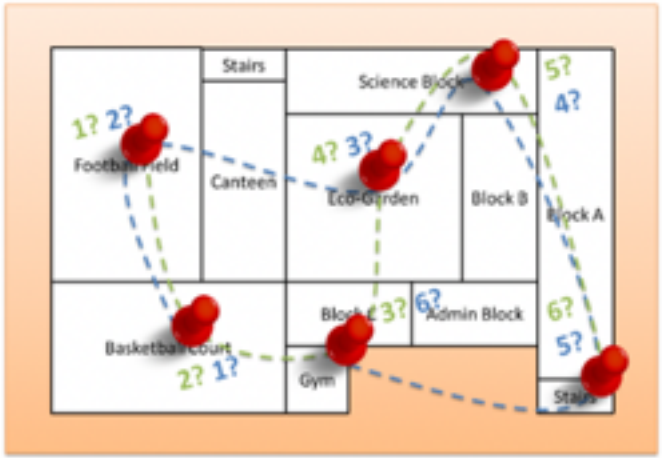
Step 5: Write the last digit of the result below the current column.

Step 6: If there are more digits, redefine the column on the left as the current column and go back to Step 3. Otherwise, the final answer is formed by the last row of digits.



Students are taught abstraction and modelling skills, such as the identification of inputs for a given problem.

1. The events for your school's Games Day use equipment that are fixed at different locations around the school. You have been asked to plan the order in which these events should be held to minimise the amount of travelling needed from event to event. A specific example of this problem is illustrated below:



Which set of input requirements is the most appropriate for this problem? .....

A

Input
• *Distances*: table of events and the travelling distance between any two events

B

Input
• *Equipment*: table of events and the equipment used for each event

C

Input
• *Map*: map of school • *Events*: list of event descriptions

D

Input
• *Teachers*: table of events and the teachers-in-charge for each event

Students are taught to identify situations where decomposition would be useful for problem-solving.

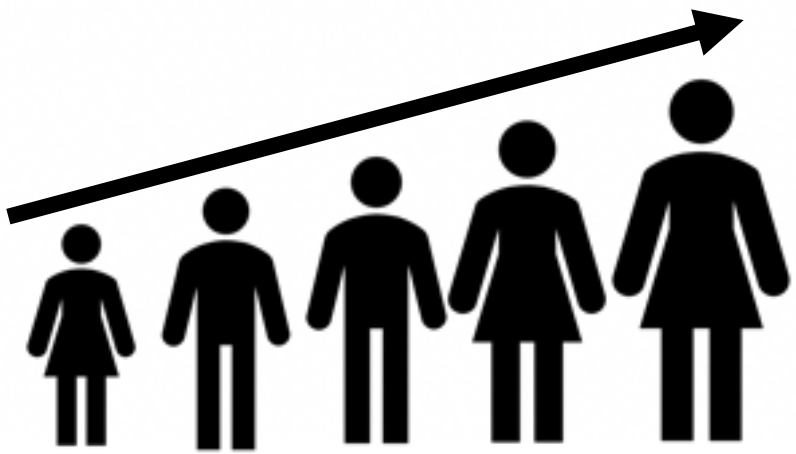
2. You wish to sort the students of your class in ascending order of height. Why is this problem difficult to solve in one step?

A There are many classes in your school

B There are many students in your class

C There are many students in your school

D The tallest student in your class is very tall



Students practice generalisation by extending a given solution to cover more cases.

6. The problem of calculating the remainder when a number is divided by 3 can be defined as follows:

Input	Output
• *Number:* a positive whole number	• Remainder when *number* is divided by 3

A possible solution to this problem is as follows:

Step 1: If *number* is less than 3, proceed to Step 3. Otherwise, proceed to Step 2.
Step 2: Subtract 3 from *number* and then proceed to Step 1.
Step 3: Output *number* as the final answer.

A similar problem is as follows:

Input	Output
• *Number:* a positive whole number • *Divisor*: a positive whole number	• Remainder when *number* is divided by *divisor*

Generalise the first solution so it solves the second problem.

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Mathematics Education

In Singapore

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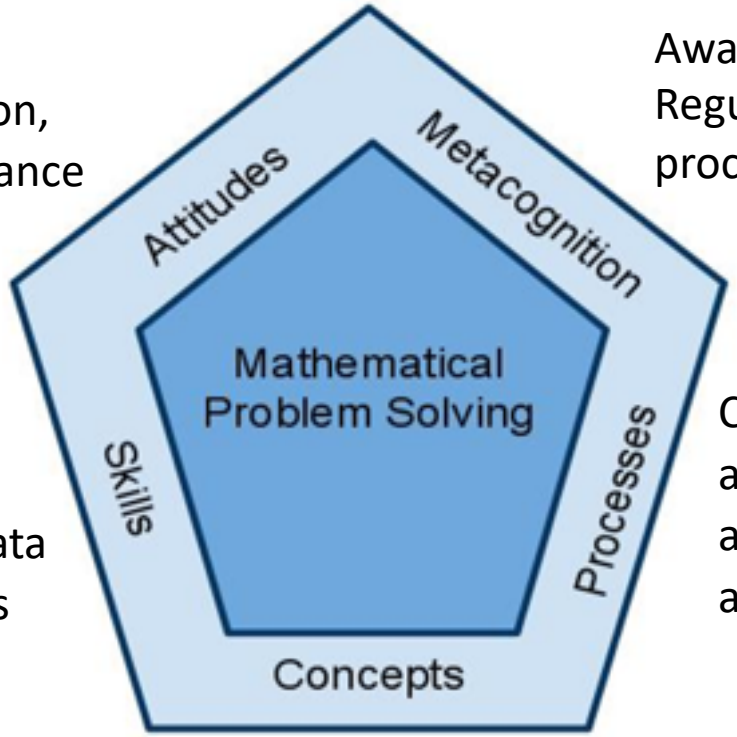
Aims of Mathematics Education

- Acquire and apply mathematical concepts and skills;
- Develop cognitive and metacognitive skills through a mathematical approach to problem solving; and
- Develop positive attitudes towards mathematics.

Mathematics Curriculum Framework

Belief, Appreciation, Confidence, Motivation, Interest and Perseverance

Awareness, Monitoring and Regulation of thought processes



Proficiency in carrying out operations and algorithms, visualising space, handling data and using mathematical tools

Competencies in abstracting and reasoning, representing and communicating, applying and modelling

Understanding of the properties and relationships, operations and algorithms, of concepts

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Mathematics Curriculum

Primary

Laying a strong foundation

Common maths curriculum up to Pri 4

Differentiation or Subject-based banding at Pri 5

Key stage exam at end of Pri 6 (i.e. Grade 6)

Secondary

Building up strengths

Three maths syllabuses to cater to different strengths & interests

Additional maths electives at Upper Sec

Key stage exam at end of Sec 4 (i.e. Grade 10) or Sec 5

Pre-University

Gearing up for tertiary education

Four maths syllabuses to cater to different strengths & interests

Graphing calculators a part of teaching & learning

Key stage exam at end of Pre-U 2 (i.e. Grade 12) or PreU 3

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Statistics Curriculum

And Statistical Thinking

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Statistics Curriculum

Primary

Data and graphs

Using and interpreting simple statistical diagrams (e.g. picture graphs, bar graphs, pie charts)

Secondary

Descriptive stats and intro to probability

Statistical diagrams (e.g. histogram, stem-and-leaf), measures of central tendency and spread, and probability

Pre-University

Probability, moving from univariate to bivariate data & inferential statistics

Probability, probability distribution models, hypothesis testing, correlation and linear regression

Developing Statistical Thinking

Examples of learning outcomes and experiences suggested in the Secondary Maths Curriculum:

- Compare various statistical representations and justify why a particular representation is more suitable than others for a given situation.
- Discuss and compare the means and standard deviations of two sets of data and interpret these values in the context of the problem.
- Make informed decisions, predictions and inferences using data.

Developing Statistical Thinking

Examples of learning outcomes and experiences suggested in the Pre-University Maths Curriculum:

- Discuss ways to perform a random selection from a population.
- Solve problems involving healthcare, product testing, consumer preferences, lifestyle choices and quality control.
- Use of appropriate regression line to make prediction or estimate a value in practical situation, including explaining how well the situation is modelled by the linear regression model.

Developing Statistical Thinking

Examples of teaching strategies suggested in the Pre-University Maths Curriculum:

- Using real-world contexts and data
- Getting students to carry out statistical investigations

RAIN, RAIN, GO AWAY

Notes to Teachers

This task can be used at the start to show students the potential applications of statistical concepts and skills that they would be learning or as a summary task to pull together all the concepts and skills that have been learned or both.

Not all the tables/figures provided in the task are relevant, so students will have to decide and select what to use.

Concepts and Skills Required

Mathematical

Sampling, hypothesis testing, modelling

Connection

Geography

Others

Critical thinking, Collaboration and Information Skills

Context

Singapore receives a lot of rainfall throughout the year, but especially in the months of November, December and January, during the Northeast Monsoon season. Since the historical floods in the 1970s, which required the authorities to evacuate people from their homes, flood-prone areas in Singapore have been significantly reduced from more than 3000 ha to the current 56 ha. However, the heavy and intense rainfalls on 16 and 17 October 2010 resulted in flash floods in Orchard Road and various low-lying parts of Singapore.

According to the NEA, on average for Singapore, there are 19 rainy days each in November and December, and 15 rainy days in January. With seemingly more frequent occurrences of flash floods though, there could be a public perception that the overall and monthly rainfall amount in Singapore has increased.

Task

Some data on the rainfall in Singapore are provided in the Annex. You may also use any other data sources that can help you in this task. Please cite the sources if you do so. Study these data and answer the following questions related to the public perception.

Are There More Rainy Days?

Based on the data, are we able to predict the total number of rainy days in 2011? If so, describe the method and explain how accurate the prediction is. If not, explain why it is not possible to do so.

Has the monthly rainfall increased?

There is a public perception that rainfall has increased over the years. Determine if there is sufficient evidence that the mean monthly rainfall amount is more than 200 mm. Explain how you would sample the data and state any assumptions that you made, and your conclusion.

Modelling Rainfall

Looking at the data, explain if it is appropriate to model the monthly rainfall in Singapore using a normal distribution.

[Hint: You will need to consider what factors are necessary for modelling rainfall.]

Figure 1: Average rainfall in Singapore from 1869 to 2010

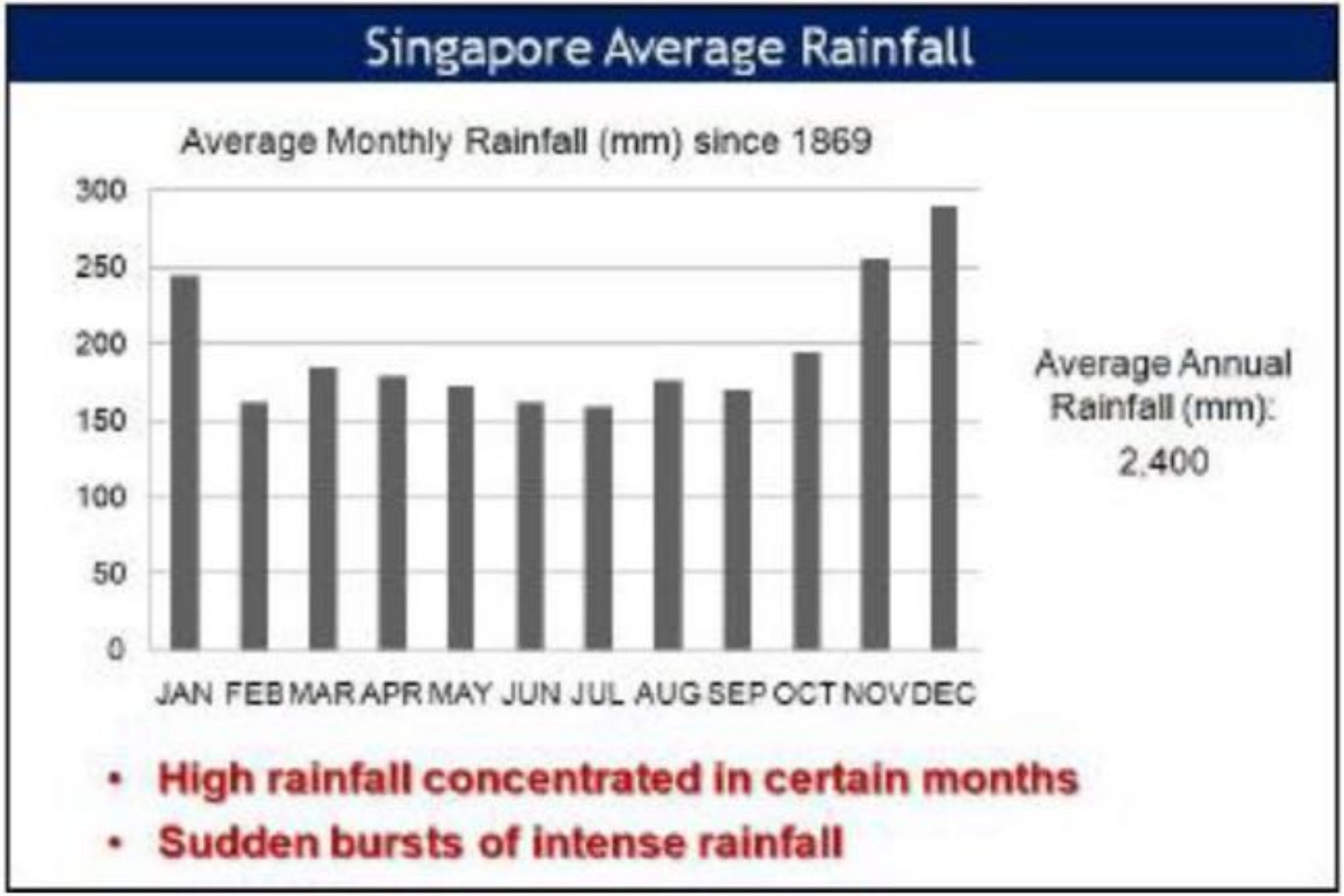
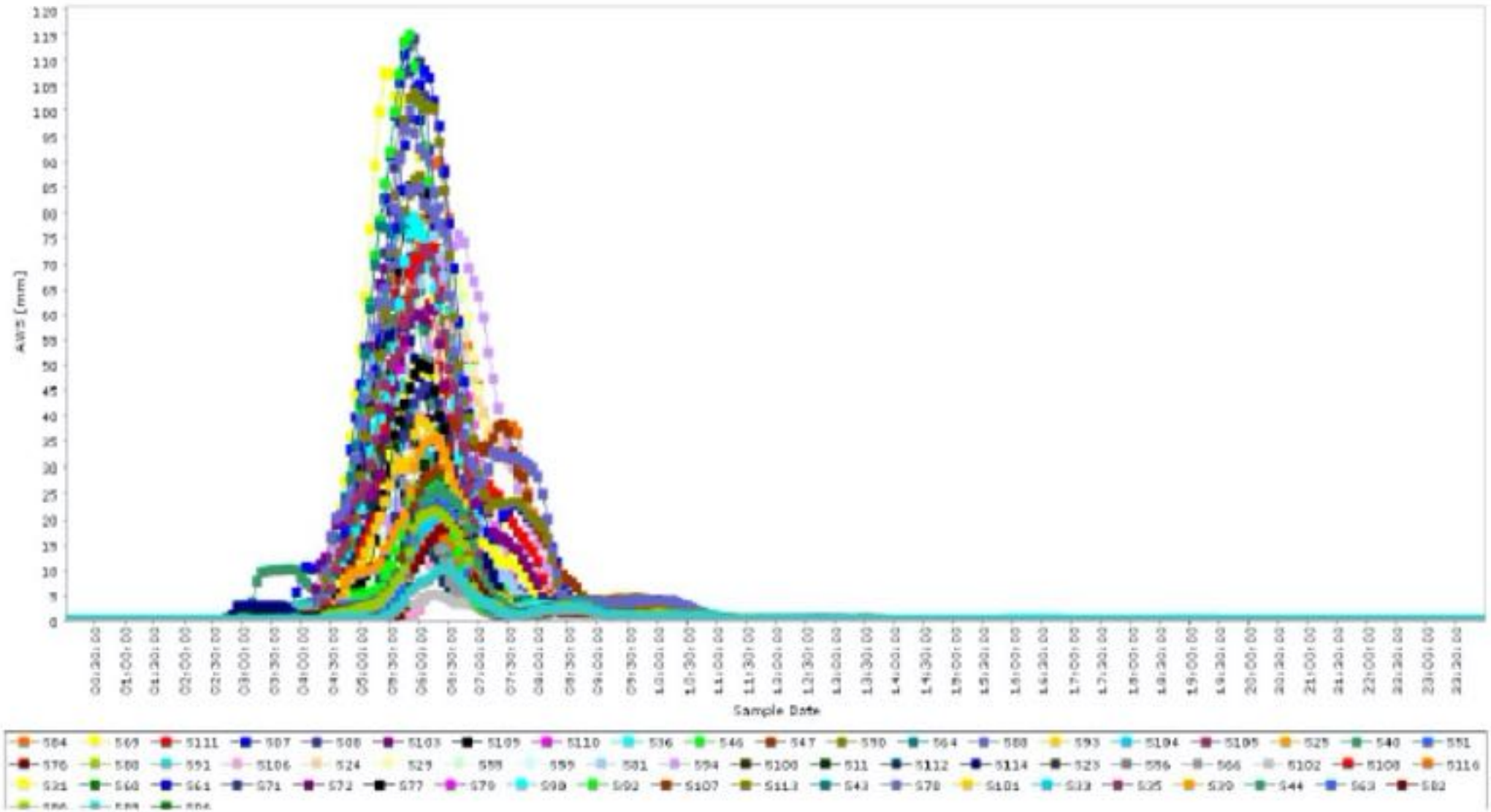
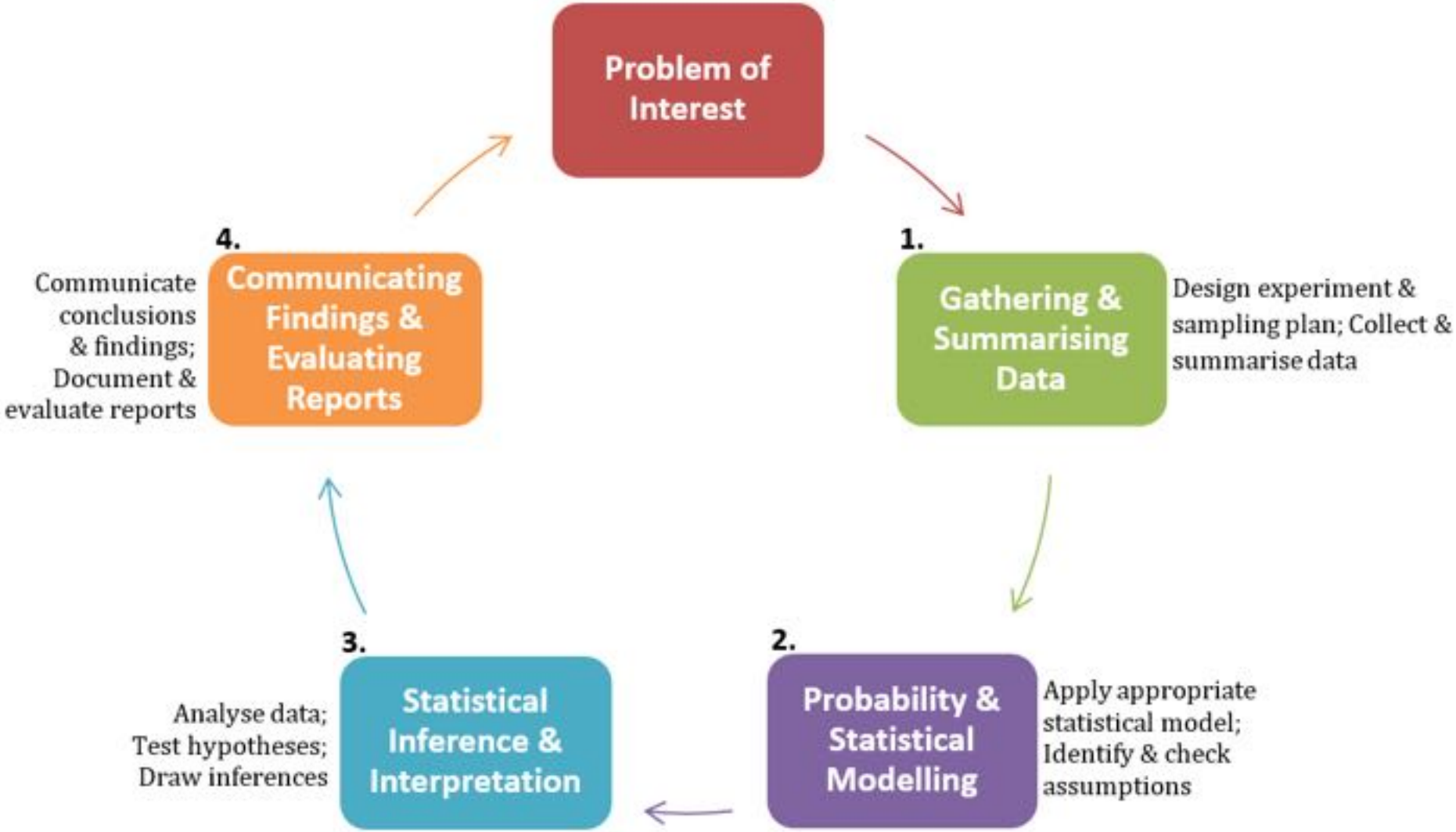


Figure 2: Rainfall data from automatic weather stations located islandwide on 17 Jul 2010



Statistical Investigation Cycle



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Our Initial Foray into Big Data

National Science Experiment Data Challenge (held from 2015-2017)

- A mass participation event to gather data about the environment and lifestyles of Singaporeans.
- Students wear SENsg devices or wearable ‘laboratories on a lanyard’ that sense the physical world and send data to the cloud.
- Objective: To allow students to learn about big data analytics, e.g. Processing and filtering of big data, use of big data tools, draw meaningful insights from big data, and presentation of analyses in easy-to-understand ways.

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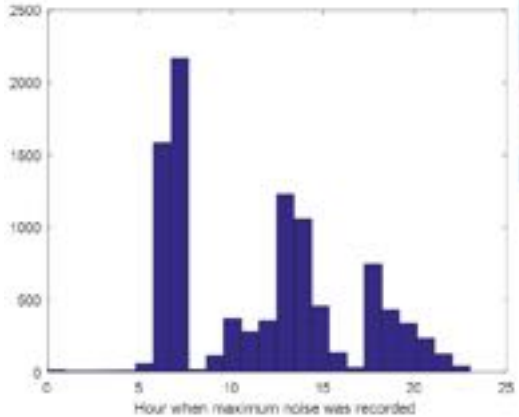
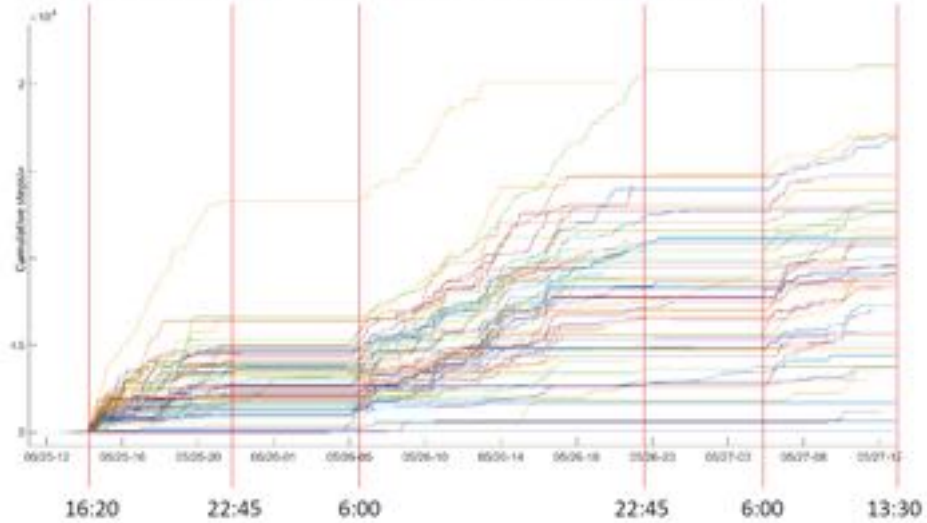
When are students noisiest?



- The loudest noises are measured before students reach school, and after they are dismissed
- There is a near-universal lull in noise in the early afternoon (studying? resting?)

When are students most active?

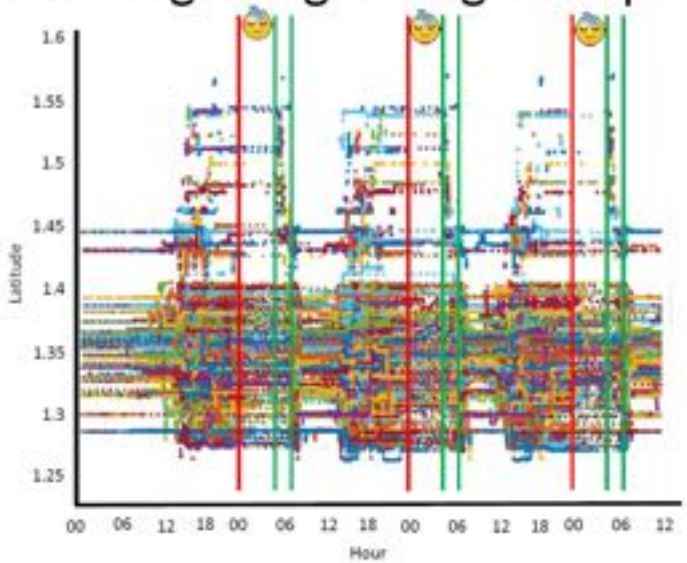


Students are 2x more active after school, as measured by steps

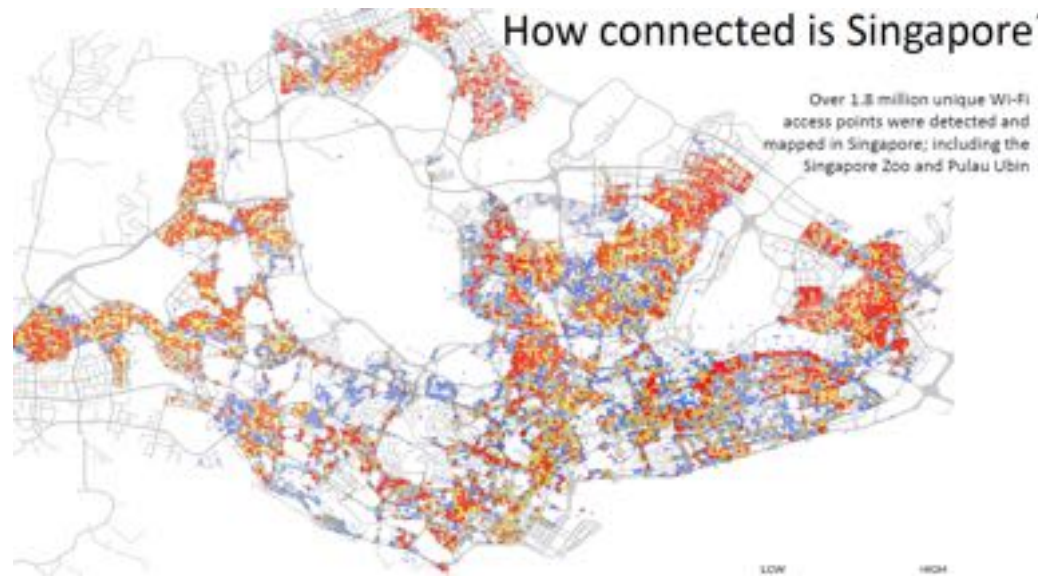
Are students getting enough sleep?

Sensors are typically awake & worn from 6AM until >10PM over 16h of activity!

(700 sensors shown)



How connected is Singapore?



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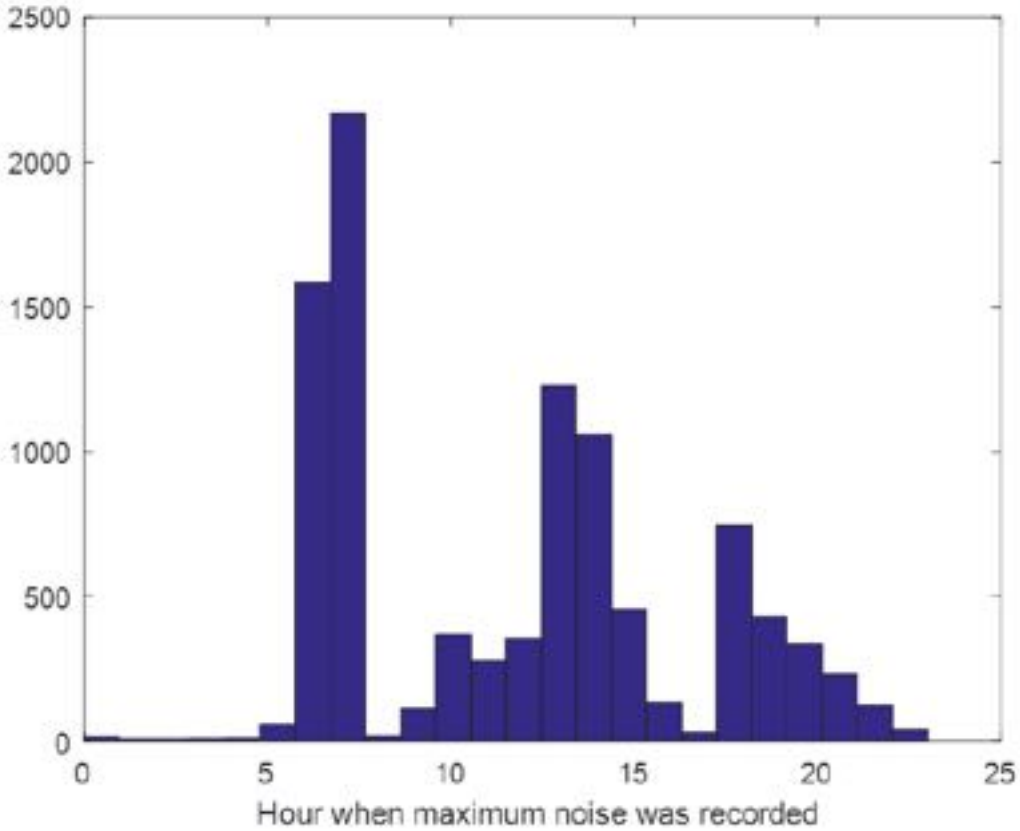

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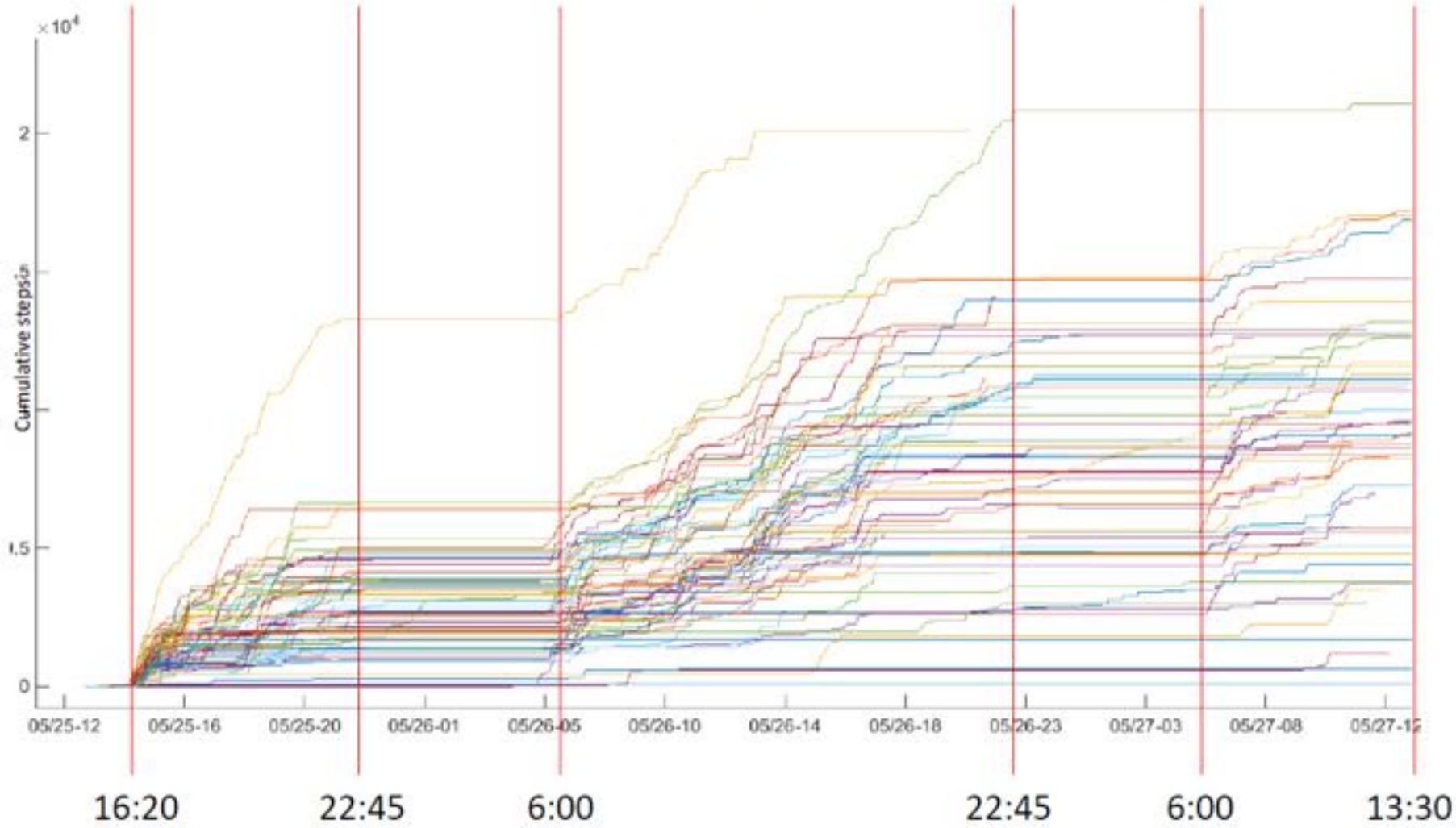

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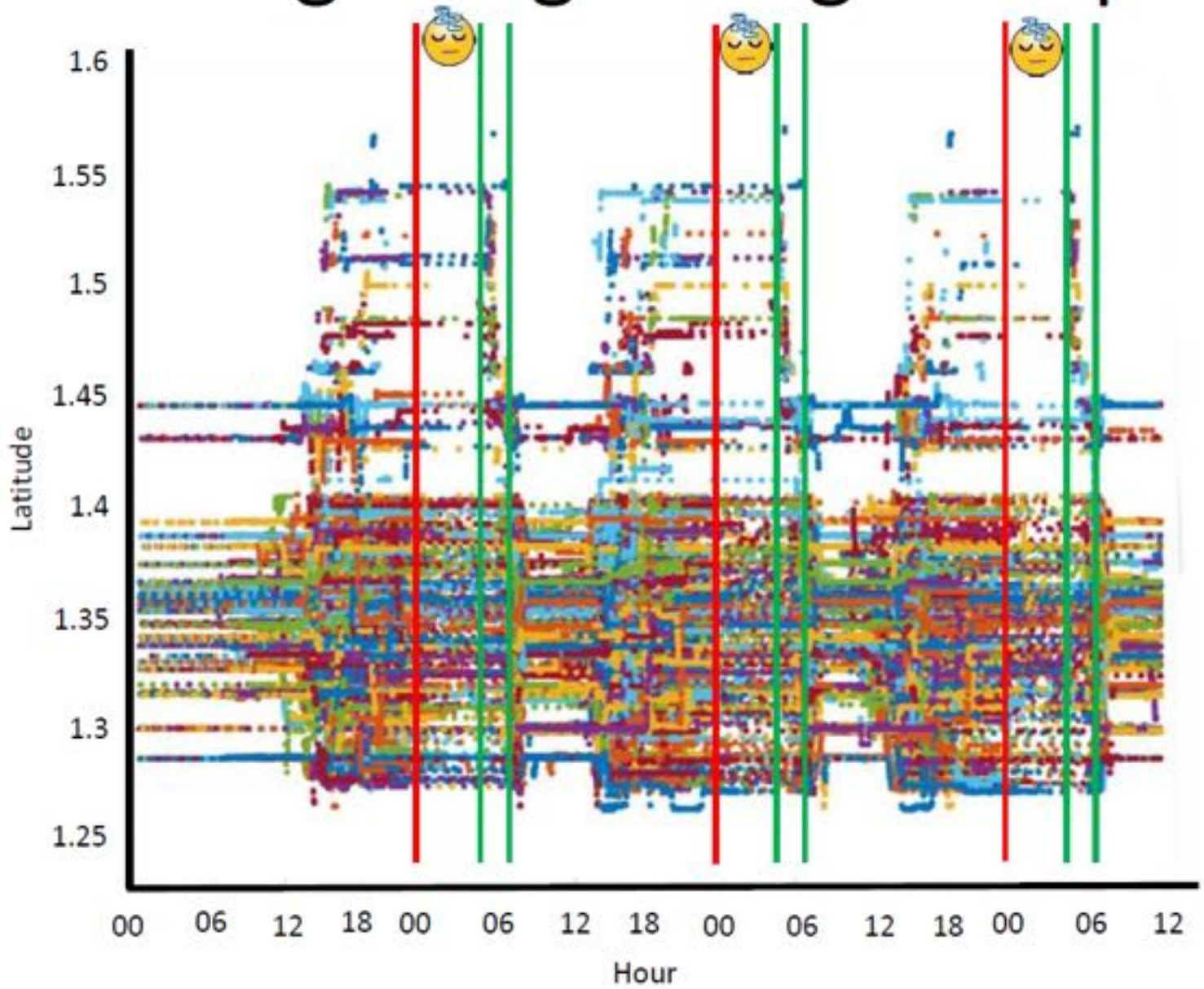

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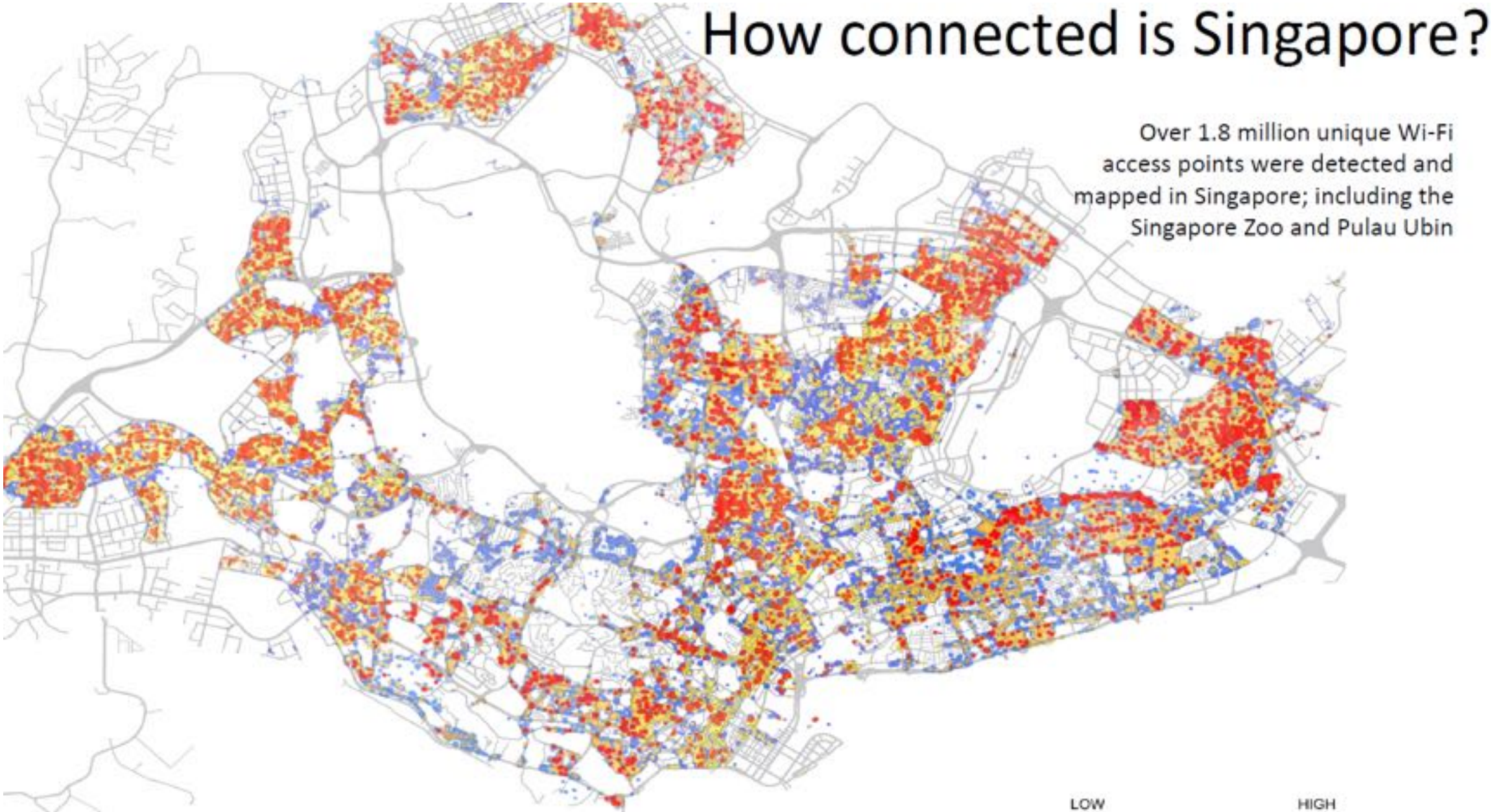

Our Approach to Developing Statistical Thinking

- Within formal curriculum: Largely traditional, with emphasis on acquiring fundamental statistical concepts and tools. Teachers are encouraged to provide, where possible, authentic learning experiences for students in learning Statistics.
- Beyond formal curriculum: Still exploring and learning.
- To some extent, the following phases in the proposed Statistical Thinking Framework are seen in our Statistics curriculum:
  - Patterns and relationships from data
  - Questions and Objectives

Challenges

- Balancing the need for curriculum time to build fundamental statistical skills and to carry out big data-related activities.
- Getting access to data sets that can provide meaningful experience for students to work with big data.
- Equipping teachers with the skills and know how to design meaningful activities involving big data.
- Changing the current emphasis and mindsets towards the learning of statistics.

Thank you

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