Education Bureau
School-based Curriculum Development (Secondary) Section
2024/25 School Year

# Utilising open data for mathematical modelling

Carmel Secondary School

# SCHOOL BACKGROUND

## Mathematics teachers

- Young, passionate, and enthusiastic team.
- Eager to implement new learning and teaching strategies.
- Concern about limited lesson time to cover the entire curriculum.

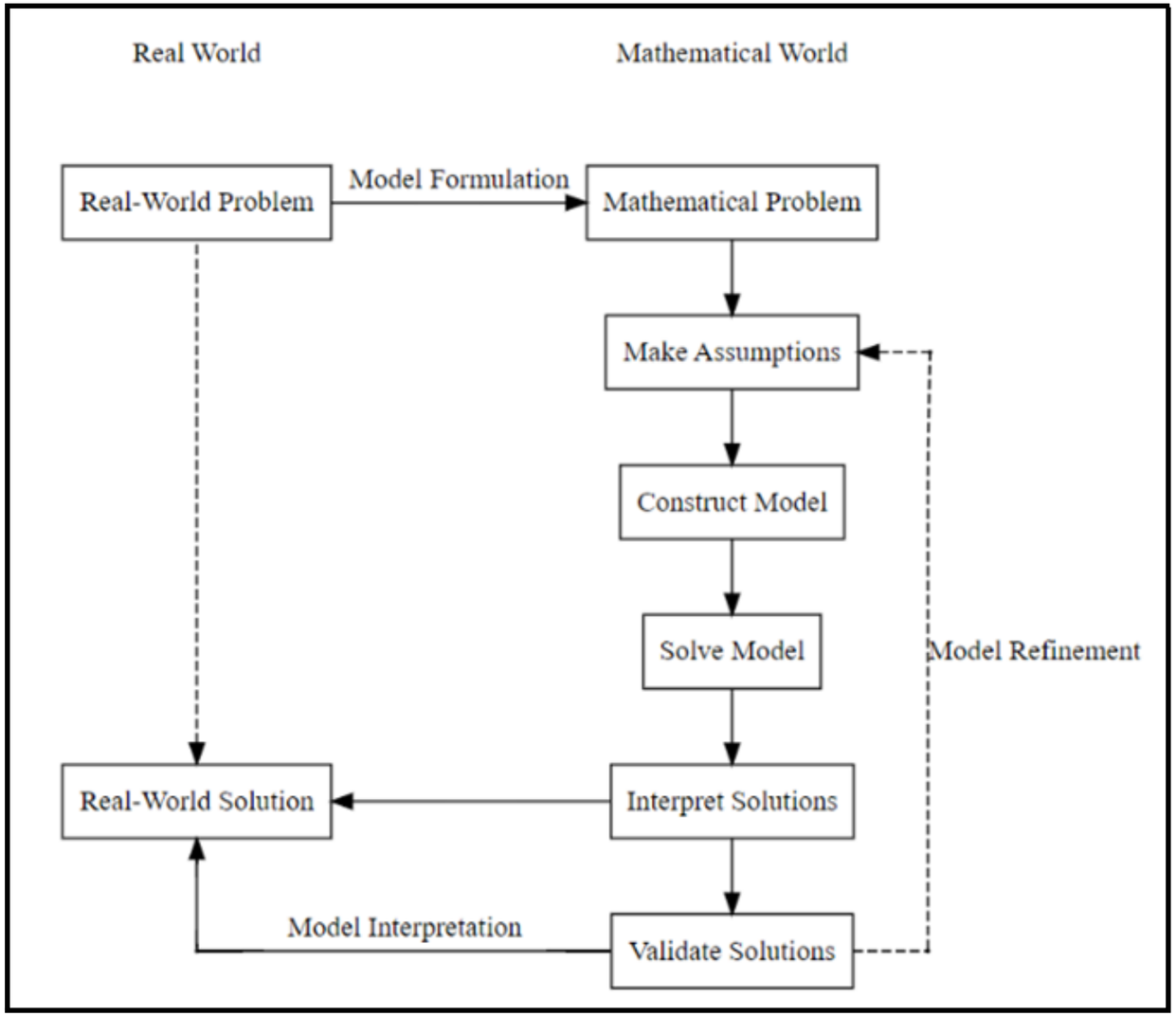
## Our students

- Many students possess great potential in terms of learning ability, generic skills, and creativity.
- Students are generally passive in their mathematics learning and are quite exam-oriented.
- Students may not always have the opportunity to demonstrate their strengths in the mathematics classroom or real-life context.

**Focus of collaboration:** Utilising open data for mathematical modelling

# MATH. MODELLING INTRO

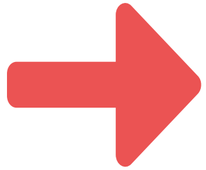
- Make assumptions
- Construct mathematical model to connect authentic data with mathematical functions
- Apply the model to make predictions and draw conclusions




Ang, K.C. (2019). Mathematical Modelling for Teachers: Resources, Pedagogy and Practice (1st ed.). Routledge.

# MATH. MODELLING INTRO

- Real-World Problem
- Authentic Data



- Mathematical Problem
- Mathematical Function

**(Graph of Functions in S4 Mathematics)**

- Authentic Data Source
  - Datasets used in the lesson are all real world data!

開放數據平台 DATA.GOV.HK

kaggle

WORLD BANK GROUP

# WARM-UP ACTIVITY

## Graphs and Equations of Functions – Desmos Card Sort

Card Sort about Graph and Equations of Functions (a,b,c are constants)

Continue to try! 🧐 🧐

$y = ax^b$

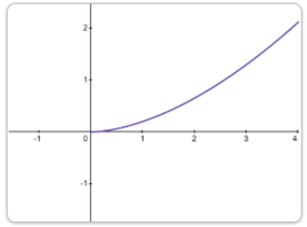
Logartihmic Function

$y = ax + b$

$y = ax^2 + bx + c$

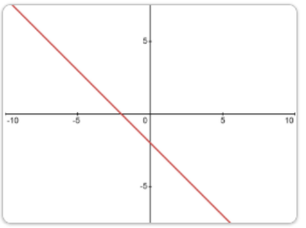
Quadratic Function

$y = a(b^x)$

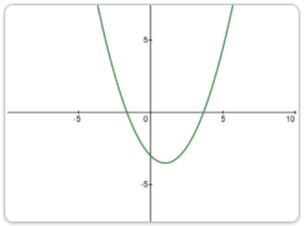


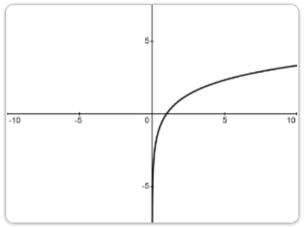
Linear Function

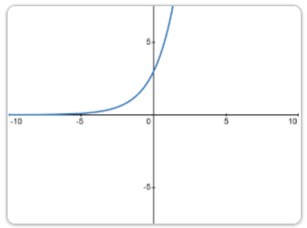
Power Function



Exponential Function







$y = a \log_b x$

# SCENARIO 1

**World Happiness Report**

The World Happiness Report reflects a worldwide demand for more attention to happiness and well-being as criteria for government policy. It reviews the state of happiness in the world today and shows how the science of happiness explains personal and national variations in happiness.

https://worldhappiness.report/about/

# SCENARIO 1

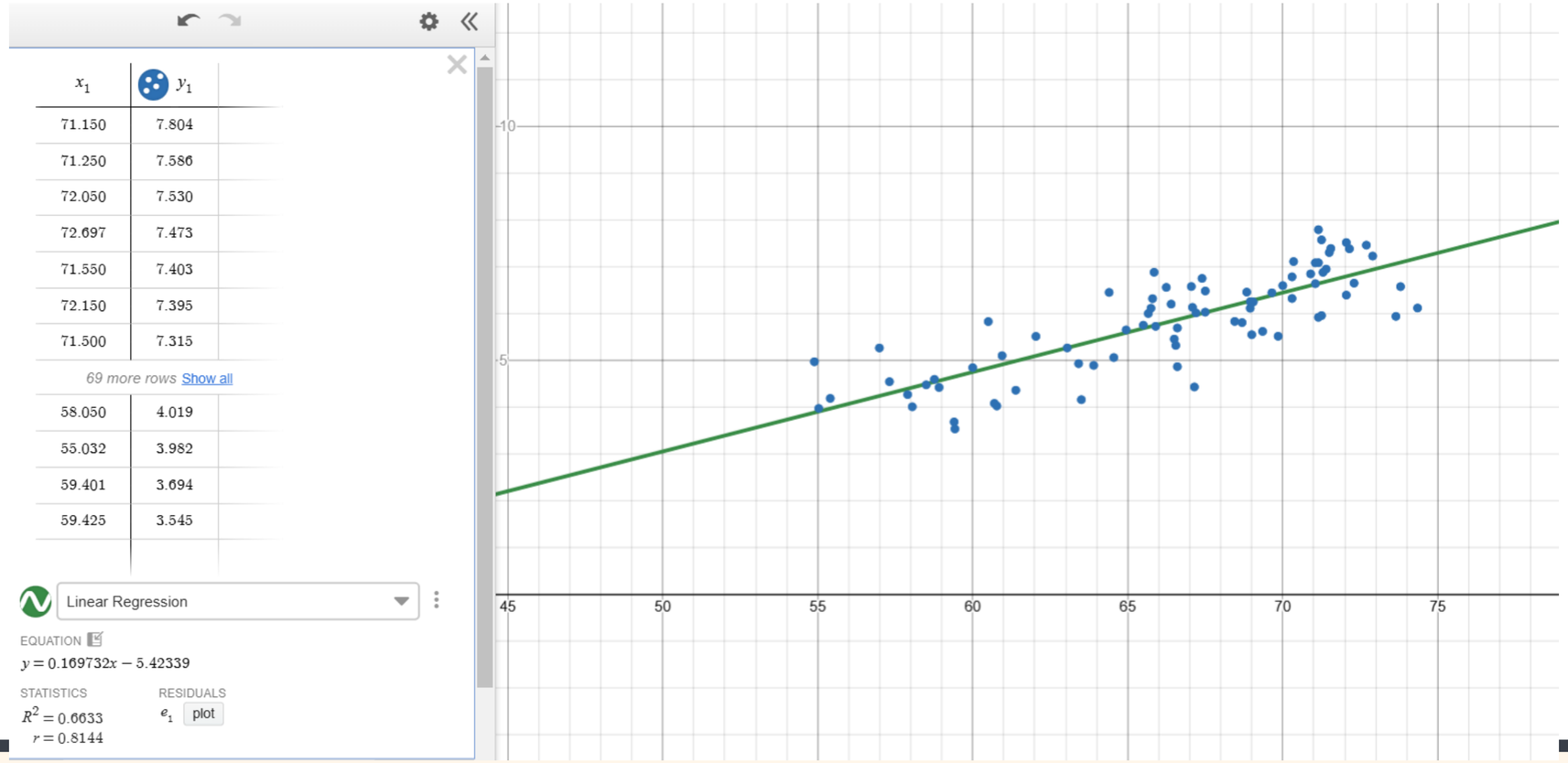
**World Happiness Index – Study the relationship of happiness score and specific factor using given data.**

- Happiness Score ~ Healthy-Life Expectancy
- Happiness Score ~ Gross Domestic Product (GDP)
- Scatter plots are generated.
- Suitable functions are chosen to fit the data.

# SCENARIO 1

## Model 1.1 - Predict “Happiness Score” by “Healthy-life Expectancy”

- What function does it look like?



| $x_1$ | $y_1$ |
|---|---|
| 71.150 | 7.804 |
| 71.250 | 7.586 |
| 72.050 | 7.530 |
| 72.697 | 7.473 |
| 71.550 | 7.403 |
| 72.150 | 7.395 |
| 71.500 | 7.315 |
| *69 more rows* Show all | |
| 58.050 | 4.019 |
| 55.032 | 3.982 |
| 59.401 | 3.694 |
| 59.425 | 3.545 |

# SCENARIO 1

## Model 1.2 - Predict “Happiness Score” by “GDP”

- What function does it look like?
- Besides linear, you can fit other functions here, let’s try !

| | |
|---|---|
| 3.209 | 3.982 |
| 2.585 | 3.694 |
| 3.212 | 3.545 |
| | |

Linear Regression

EQUATION

$y = 0.041008x + 4.73963$

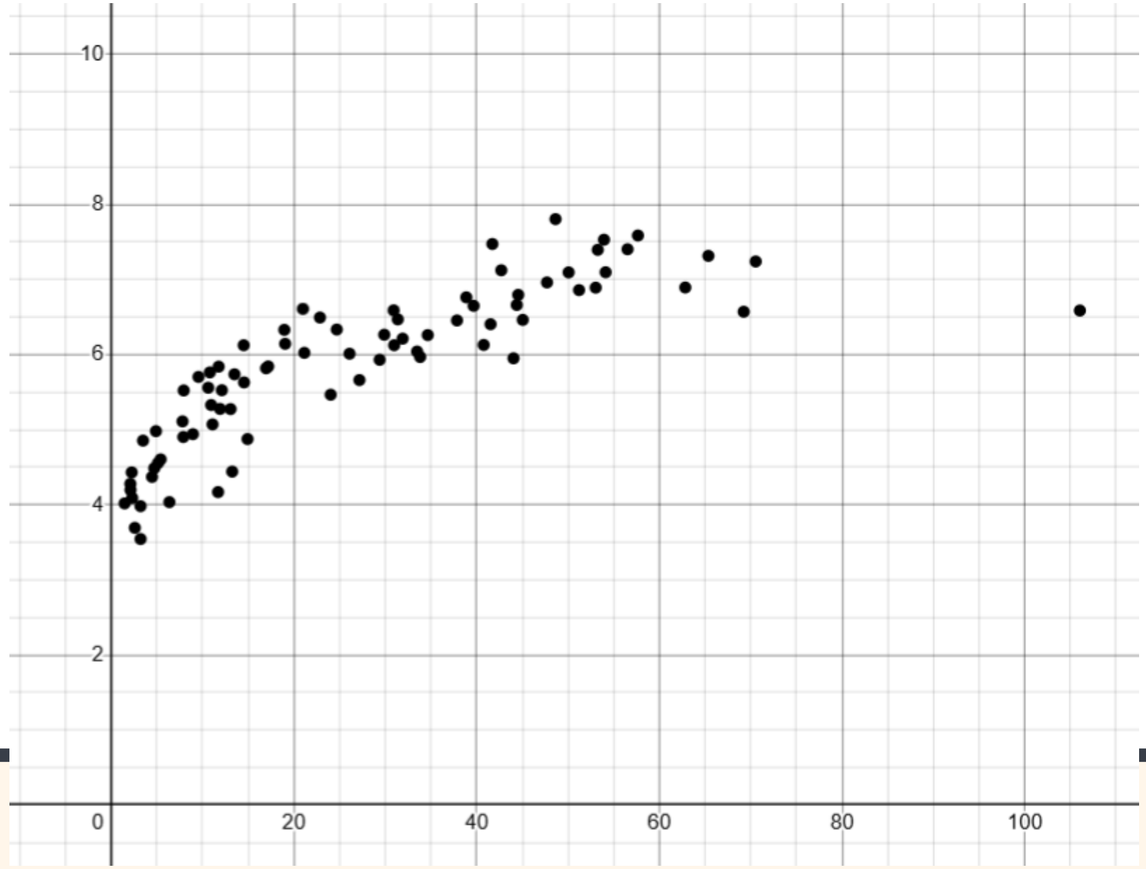
STATISTICS

$R^2 = 0.6757$

$r = 0.822$

RESIDUALS

$e_2$ plot



# SCENARIO 1

**Making predictions with model developed and checked with actual value.**

| | Healthy Life Expectancy (x) | Happiness Score (y) |
|---|---|---|
| Cambodia | 61.90 | |
| Spain | 72.35 | |

| | GDP (x) | Happiness Score (y) |
|---|---|---|
| Cambodia | 4.380 | |
| Spain | 37.809 | |
| Hong Kong | 57.898 | |

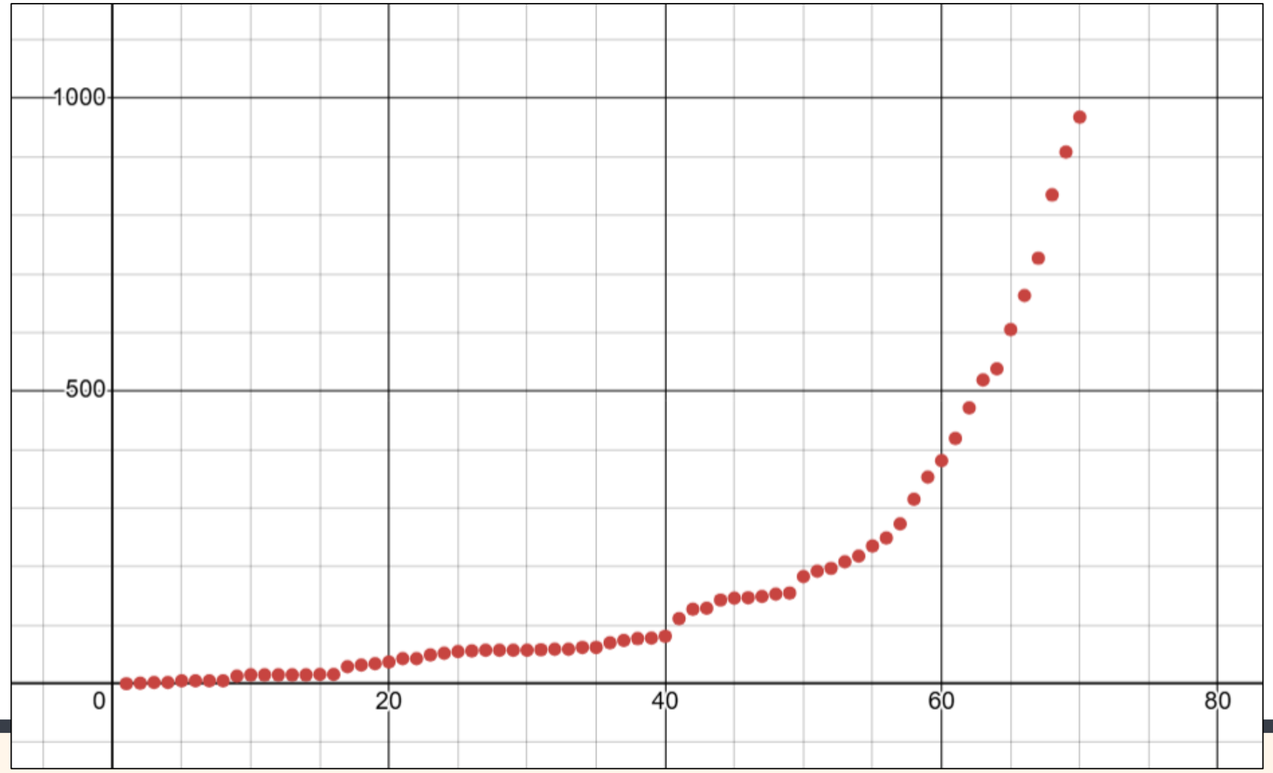
What is your comment about Hong Kong’s happiness score?

# SCENARIO 2

## Model 2 - Predict COVID-19 confirmed cases

Dataset 2 captured the number of confirmed COVID-19 cases from 13/5/2020 to 21/7/2020 .

Students model the data to identify suitable function. What function does it look like?

# SCENARIO 2

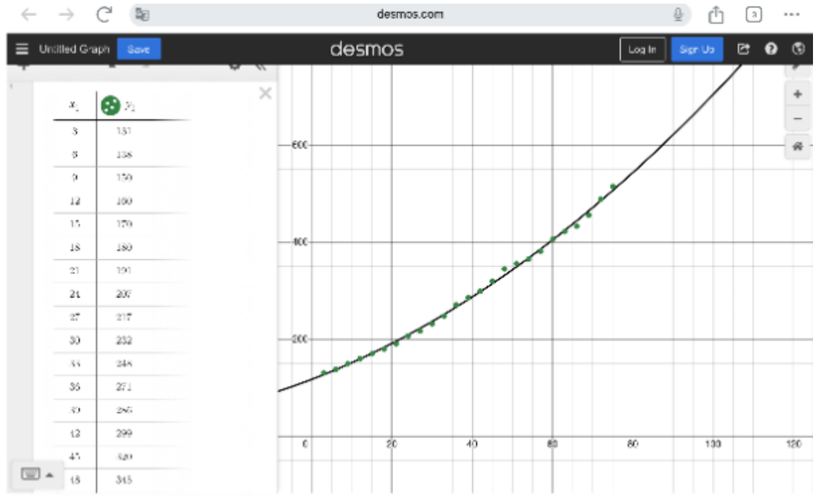
**Predict the numbers in the next few days, is our model good enough?**

| Days since 8/5/2020 | No. of Confirmed Cases [Predicted] | No. of Confirmed Cases [Actual] |
|---|---|---|
| 77 (23/7/2020) | | 2249 |
| 80 (26/7/2020) | | 2633 |

# Consolidation Exercise

## SCENARIO 3

### Trends of Spotify Users




***Write / Type / Post picture of the equation of your model:***

***y=0.0270139x^(2)+3.17009x+117.35565***

***Using your model , predict the Monthly Active Users in :***

***(1) 2023 Quarter 3 : 551.3715***

***(2) 2024 Quarter 1 :597.62216***

***(3) 2024 Quarter 3 :645.81776***

# Consolidation Exercise

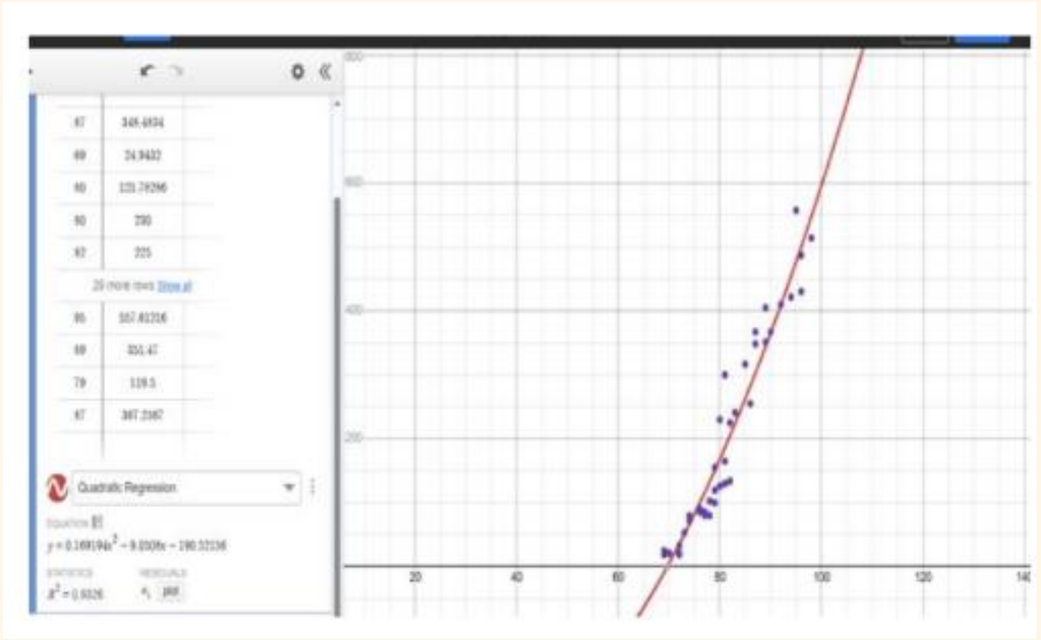
## SCENARIO 4

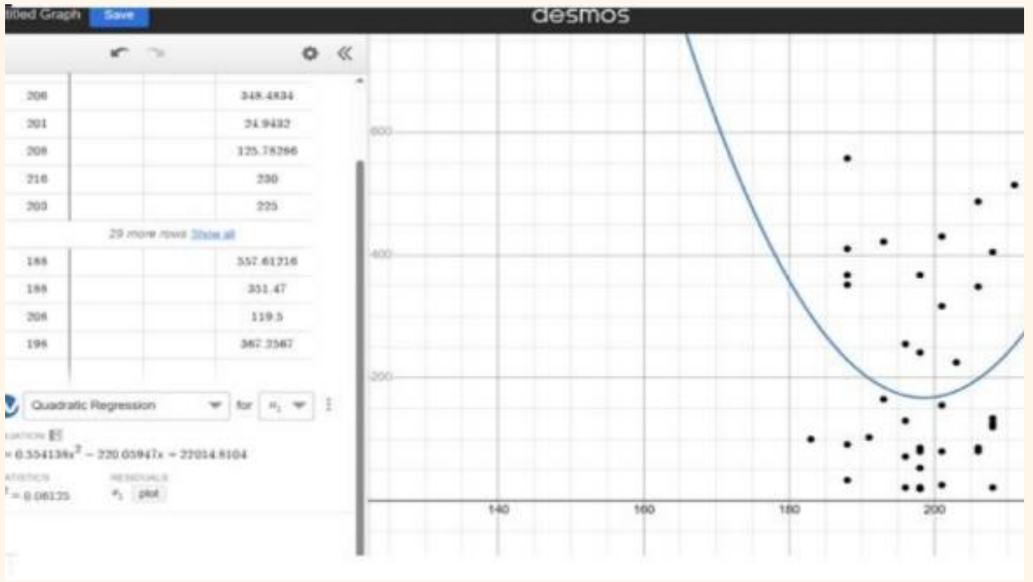
**Predict NBA player salary by NBA2K25 Game Player Data**

**Using your model and the data given, predict the player salary (in $100000).**

| name | team | position_1 | height_cm | weight_kg | overall 2K rating |
|---|---|---|---|---|---|
| Victor Wembanyama | San Antonio Spurs | C | 224 | 95 | 91 |
| Ben Simmons | Brooklyn Nets | PG | 208 | 108 | 76 |

| (Fill in the Predicted) | Predicted Season Salary | Actual Season Salary |
|---|---|---|
| Victor Wembanyama | 390.5($100000) | 127.7 |
| Ben Simmons | 98.9($100000) | 403.4 |

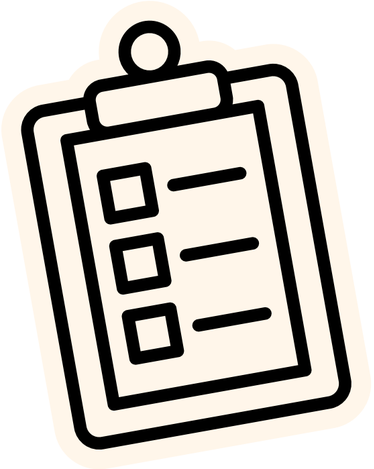


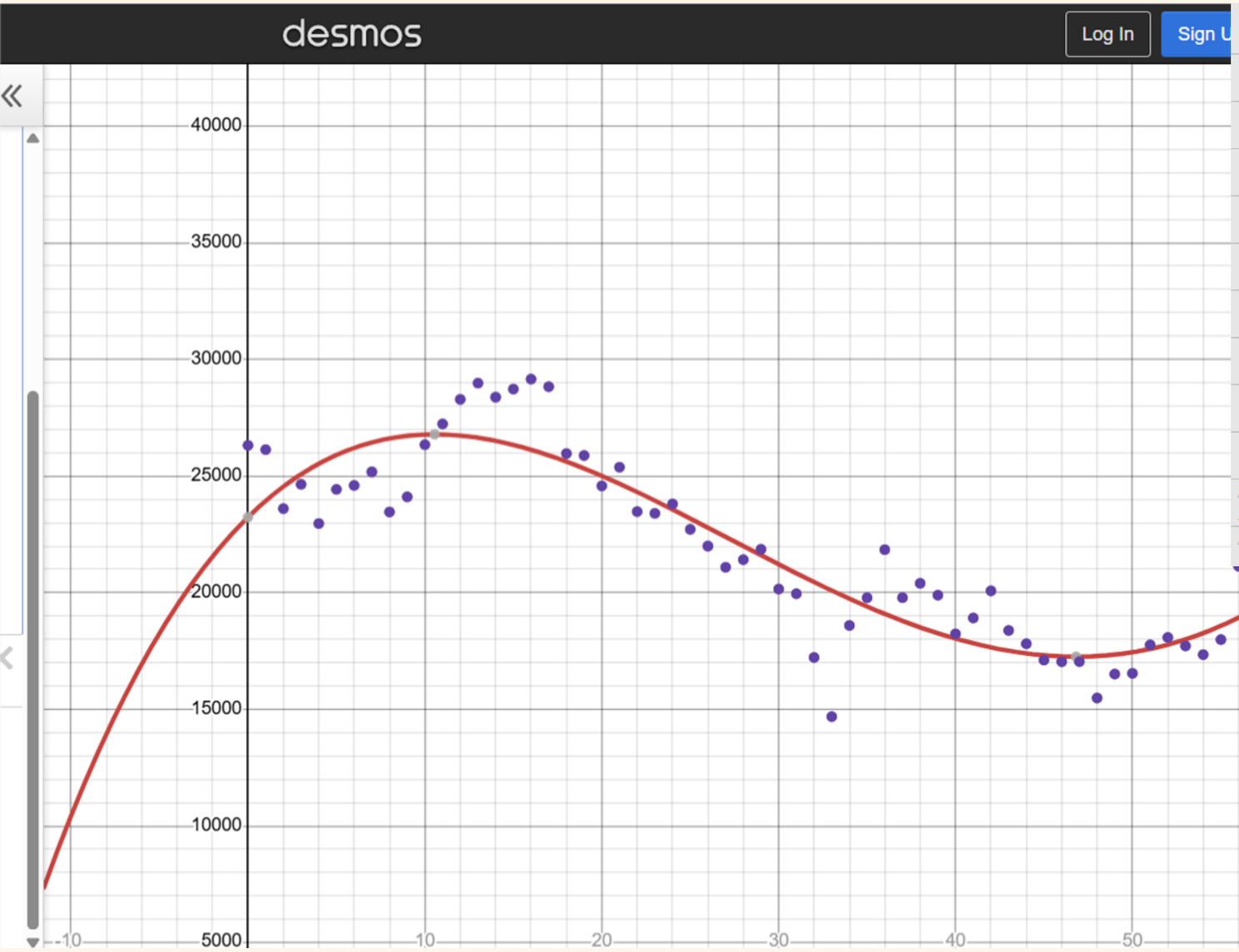
# MINI PROJECT

Form groups of 2-4 students to complete one of the following modelling mini-project.

1. City Temperature & Atmosphere Carbon Dioxide
2. Human Development Index and G.D.P.
3. Predicting Stock Price
4. Experiment : Free-falling under Air Resistance



# Student Performance in “Predicting Stock Price”




| | A | B | C |
|---|---|---|---|
| 1 | Date(mm/dd/yyyy) | Month Elapsed | Hang Seng Index |
| 2 | 1/1/2020 | 0 | 26312.63 |
| 3 | 2/1/2020 | 1 | 26129.93 |
| 4 | 3/1/2020 | 2 | 23603.48 |
| 5 | 4/1/2020 | 3 | 24643.59 |
| 6 | 5/1/2020 | 4 | 22961.47 |
| 7 | 6/1/2020 | 5 | 24427.19 |
| 8 | 7/1/2020 | 6 | 24595.35 |
| 9 | 8/1/2020 | 7 | 25177.05 |
| 10 | 9/1/2020 | 8 | 23459.05 |
| 11 | 10/1/2020 | 9 | 24107.42 |

- Write down the equation of your final model:

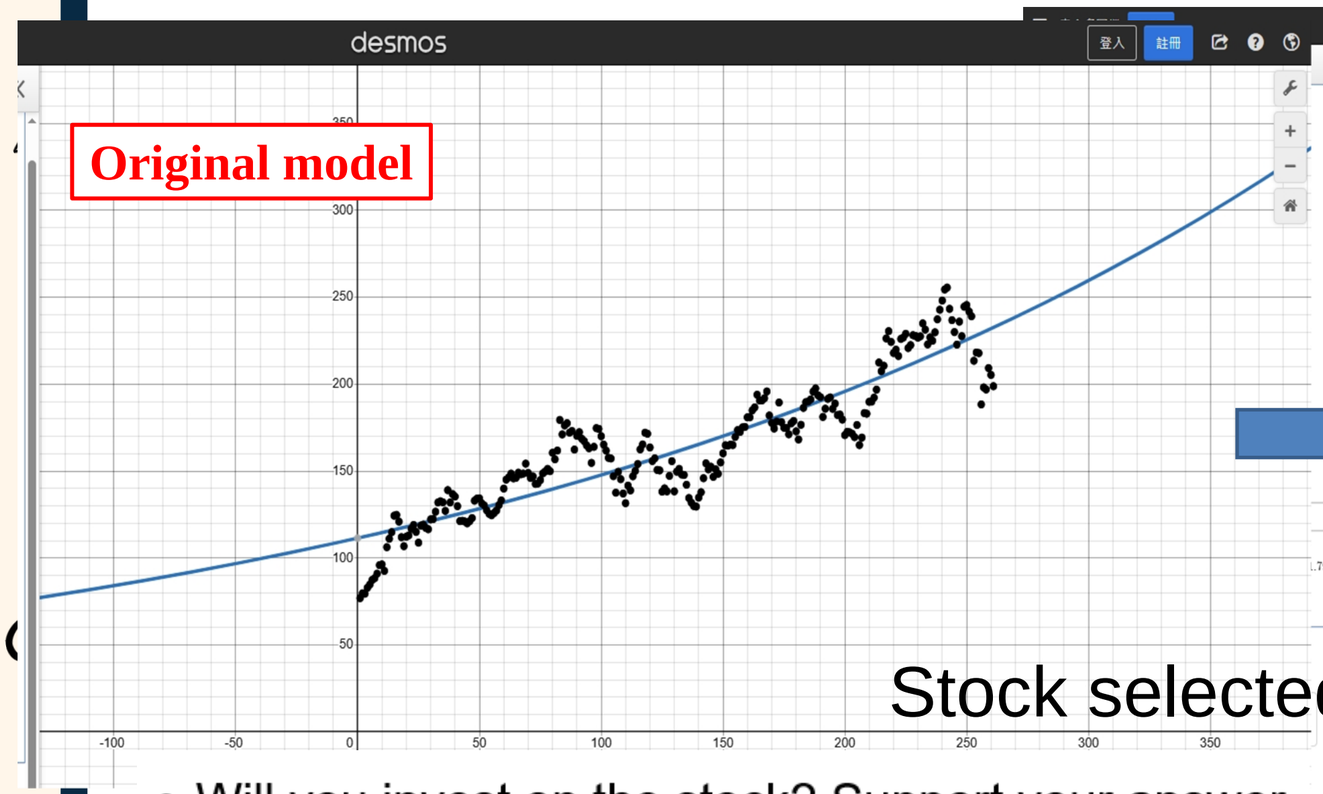
y=-0.00270833x^{4}+0.710413x^{3}-45.97844x^{2}+745.6865x+23234.8126

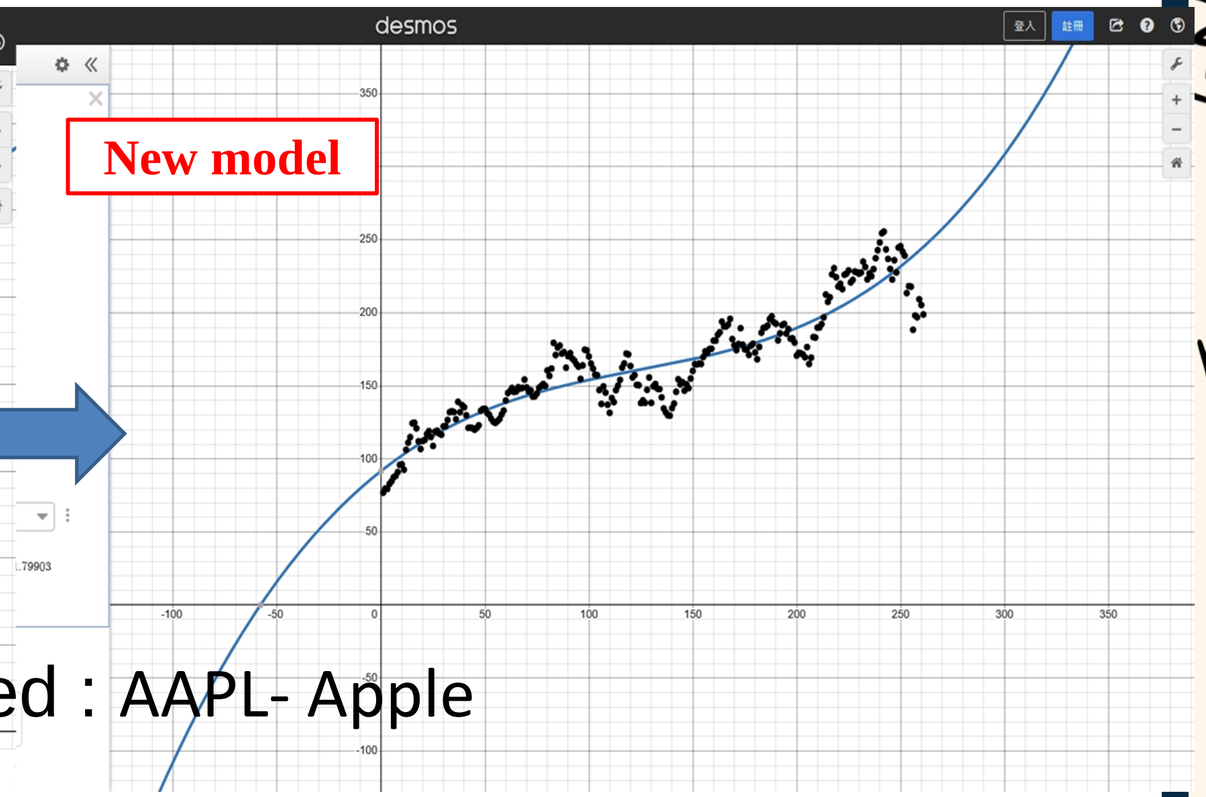
- Predict the Hang Send Index in the beginning of Feb, 2025

21386.99425

**Students used the authentic data to create a model for predicting the future Hang Seng Index value**

# Student Performance in “Predicting Stock Price”



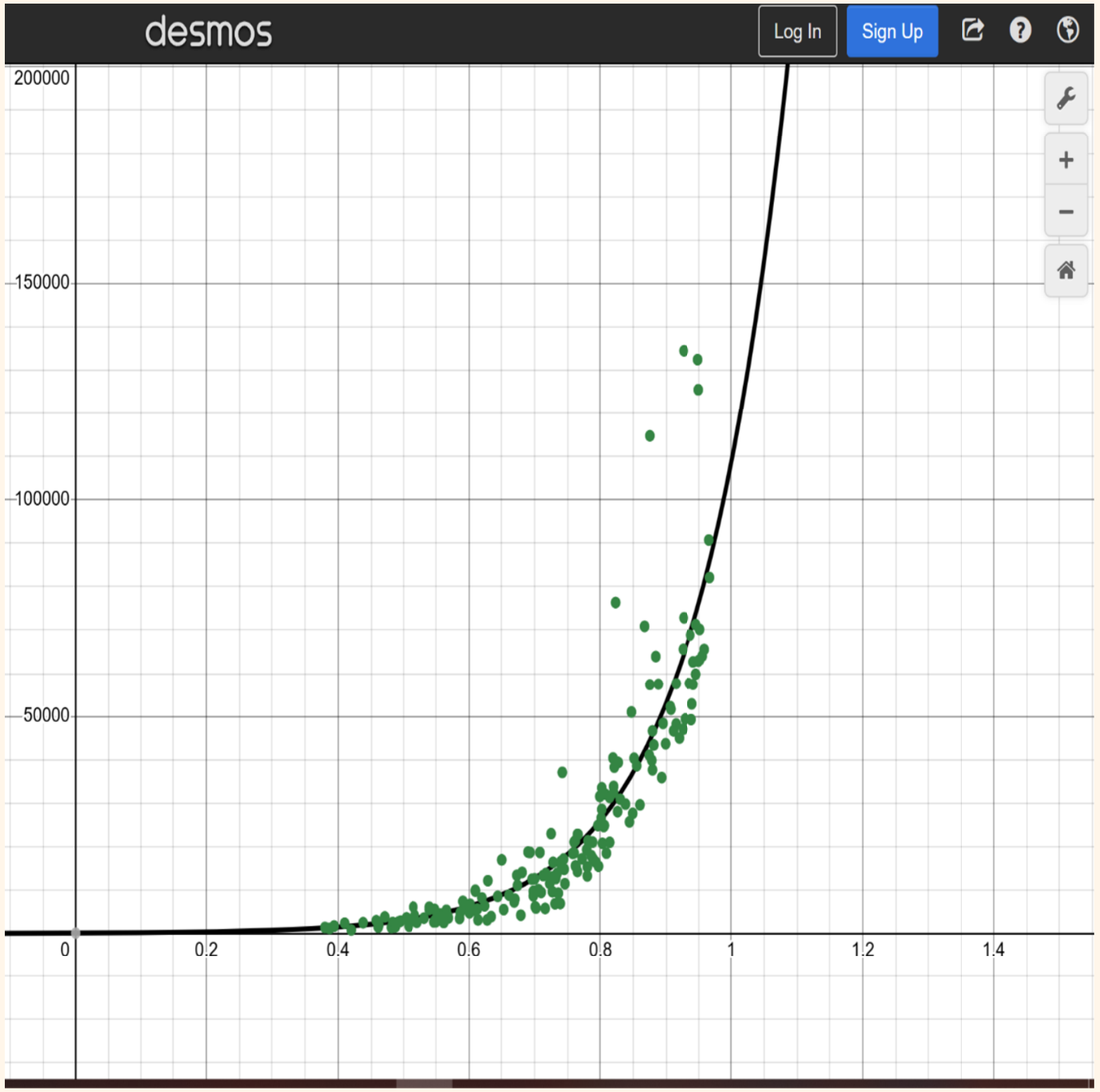

Stock selected : AAPL- Apple

- Will you invest on the stock? Support your answer with data, news and your own views.

Yes, it is because the statistic shows that the stock price of apple will increases.

**Students can refine the original model for decision making**

# Student Performance in “Human Development Index and G.D.P.”




- Write down the equation of your final model:

y=101974.958 X  x^{6.00964}

- Find the percentage error of your prediction with the actual data provided below:

Paraguay :  Actual GDP = 15259

253/15259 X 100%= 1.69% (cor to 3 sig fig)

France :  Actual GDP = 53643

12287/ 53643 X 100% = 22.9% (cor to 3 sig fig)

Is the model useful?

A bit. The percentage error for Paraguay is only around 1 % which is very little. However the percentage error for France is more than 20% which is quite a lot. It is a bit useful but in reality we still need to think, compare and interpret different data instead of totally relying on the model.

**Students justified the quality of model and understand its limitation**

# Student Performance in “Experiment : Free-falling under Air Resistance ” project

s: displacement (m)

t: time (s)

s 4.747 4.794 4.715 4.731

t ① 1.14 ~~2.03~~ (膠盤)

s 6.655 6.688 6.633 6.645

t 平均 ② 1.29 1.37 ~~1.41~~ (膠盤)

s 8.287 8.292 8.281 8.288

t ③ 1.49 1.62

s 10.214 10.175 10.177 10.290

t 平均 ④ 1.56 1.83

s 11.890 11.923 11.875 11.872

t ⑤ (1.76+1.68)÷2 1.99

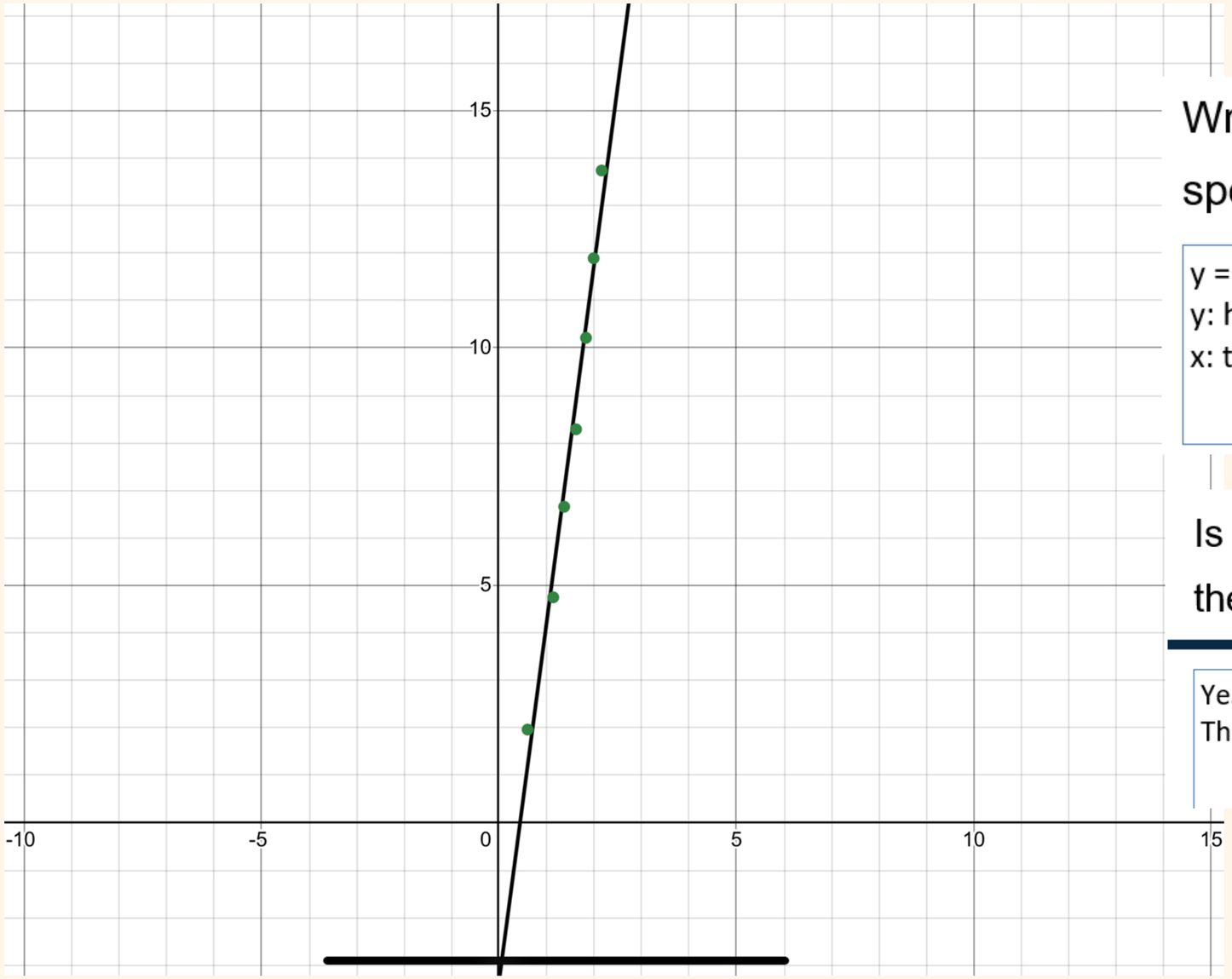
s 13.739 13.724 13.762 13.731

t 平均 ⑥ (2.14+2.18)÷2 2.16

s Jasper + hand length 1.960 0.6

**Students designed an experiment to collect authentic data**

# Student Performance in “Experiment : Free-falling under Air Resistance ” project




Write down the equation of your model, specify the meaning of variables:

y = 7.54406x - 3.32927
y: height
x: time needed to reach the ground

Is the model good? Justify your answer with the plots and the statistical measure shown in the Desmos.

Yes.
The points are close to the the line. $R^2$= 0.9798 which is very close to 1.

**Students justified the quality of model with proper statistical measure**

# Students' Reflection

- What have you learnt about mathematical modelling?
- Has the introduction of mathematical modelling changed your views and attitude towards mathematics?

Math models are effective for predicting real-life situations using existing data, although they do have some limitations since no mathematical equation perfectly suits real-life data.

I've learned that mathematical modeling is useful for predicting future data and for using one set of information to predict another – for example, using the GDP of other countries to predict Hong Kong's GDP.

This project has helped us find mathematics more interesting. We can also learn about the actual uses of different functions instead of only knowing how to calculate them in math exams.

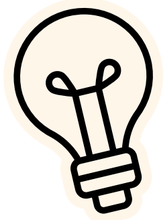
Mathematics can be applied to our society in various ways.

We all love maths even more!!!!

# CHANGE AND GROWTH

- **Transforming students' perspective:** The modelling activities successfully engaged students in the practical application of mathematical modelling in real-life scenarios. Students not only experienced the processes of mathematical modelling but also developed their confidence to contribute ideas and opinions to problem-solving.
- **Changing Teacher Pedagogy:** A slight change has been observed in teachers' attitudes towards mathematics education. Their focus has evolved from primarily covering textbook content and exam questions to designing learning activities that fostered students' mathematical thinking skills and interest.
- **Recognising the value of Mathematical Modelling:** Teachers now clearly perceive the potential benefits of incorporating mathematical modelling activities into the curriculum that can effectively increase student engagement, promote self-directed learning, and broaden students' depth and breadth of mathematical knowledge.

# REFLECTION AND WAY FORWARD



- **Explore Cross-Curricular collaboration:** Considering students' preference in taking different elective subjects, cross-curriculum approach could be adopted to further enhance the authenticity of tasks by integrating knowledge and skills from different subjects.
- **Increase Visual Data Exploration:** More visual data exploration (e.g., growth charts, weather patterns, local sports team statistics) could be used to spark discussions and facilitate basic data interpretation. This could be incorporated at the beginning of lessons or as a pre-lesson task.
- **Emphasis on Communication:** Place greater emphasis on communication. Require students to clearly articulate their modeling process, assumptions, findings, and limitations using proper mathematical language.

End