Learning & Teaching Expo

STEAM

A Study on Productive Failure as a STEM Pedagogy Catering for Diversity

照顧學習差異以建設性挫敗爲本的 STEM 教學法

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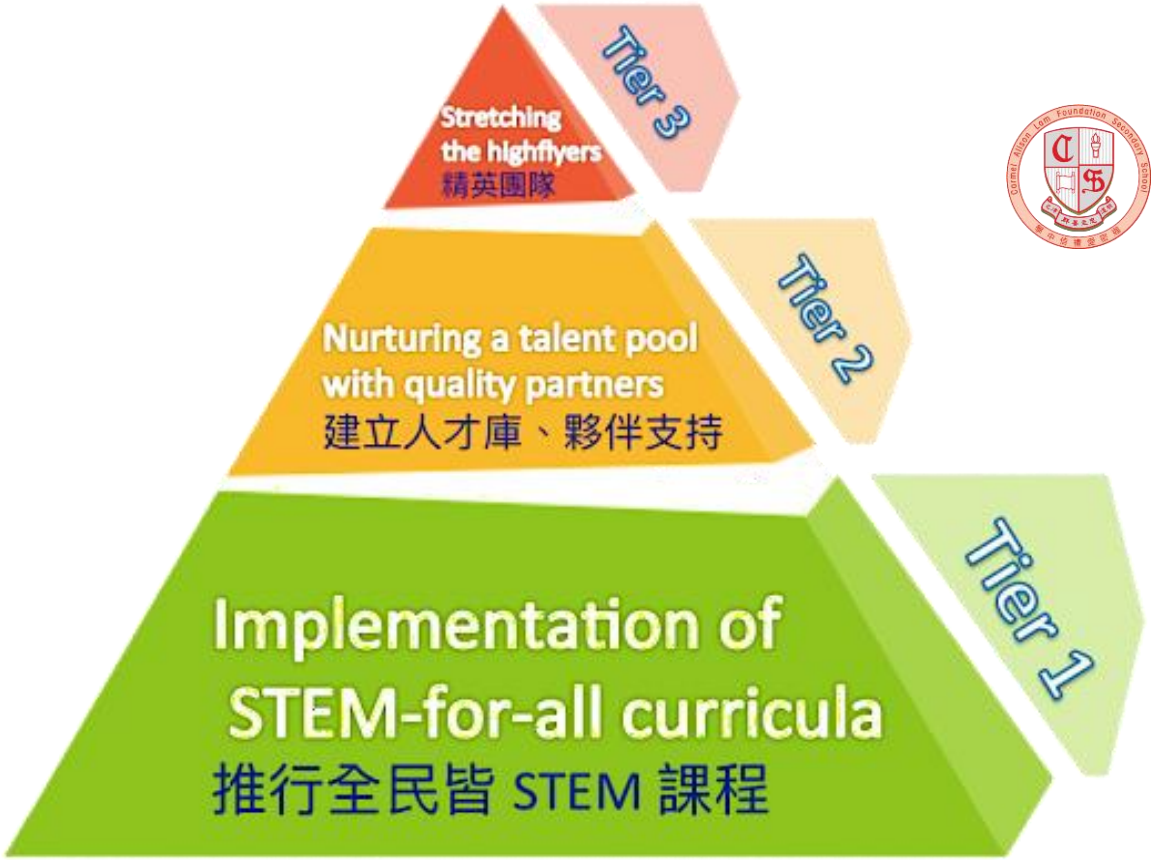
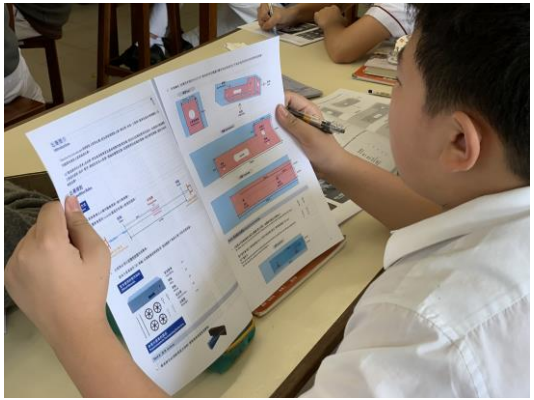
13 Dec 2019

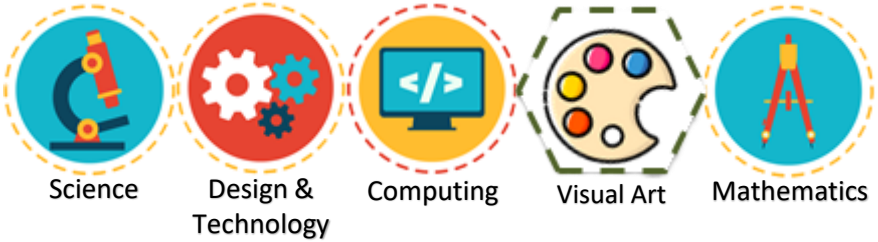
3-Tier STEAM Education



S T E A M

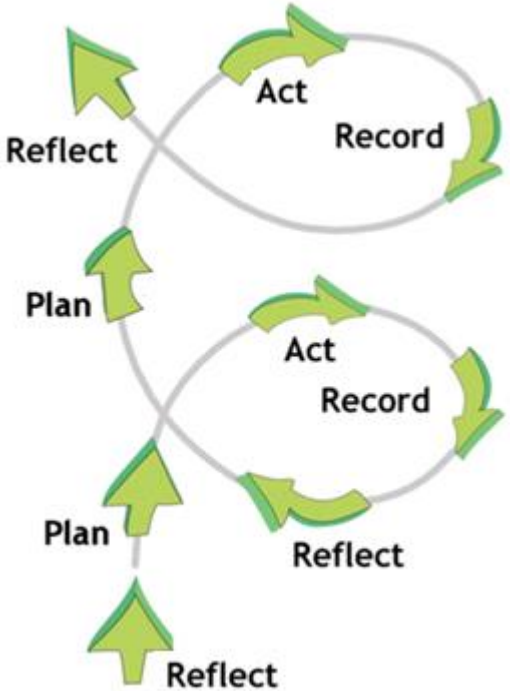
STEM-for-all Curriculum for S.2 Students





https://www.dendrite.me/competition/view/competitionid/59d50b8c08d734008f5bcae9#tab:collection-groups

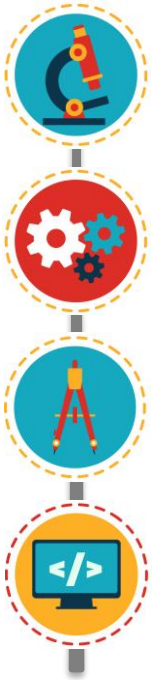
Action Research

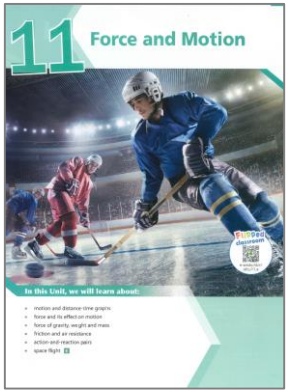


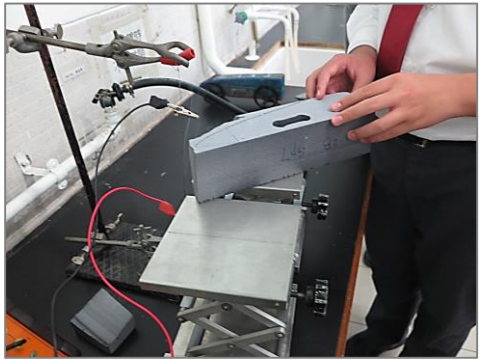
Can Productive Failure pedagogical design improve the capacity of struggling learners to acquire scientific concepts and to form complex link between them such that knowledge might be applied to solve novel problems as compared with Direct Instruction in a STEM curriculum?

http://patterns.transitionresearchnetwork.org/Action_Research.html

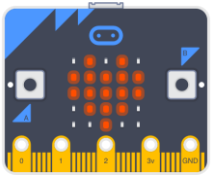
Inter-disciplinary Curricular Design





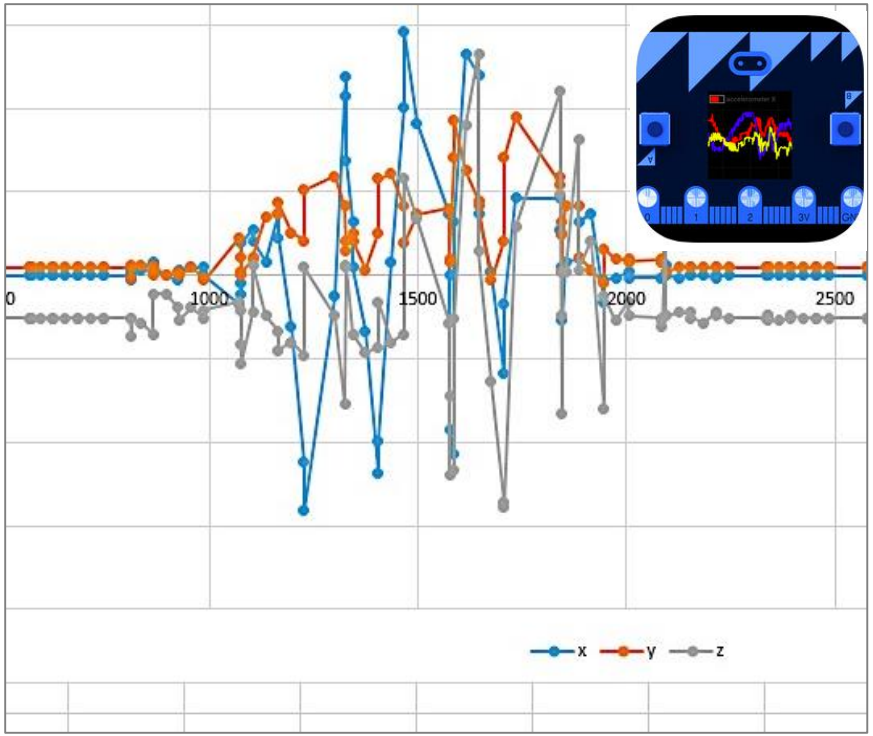


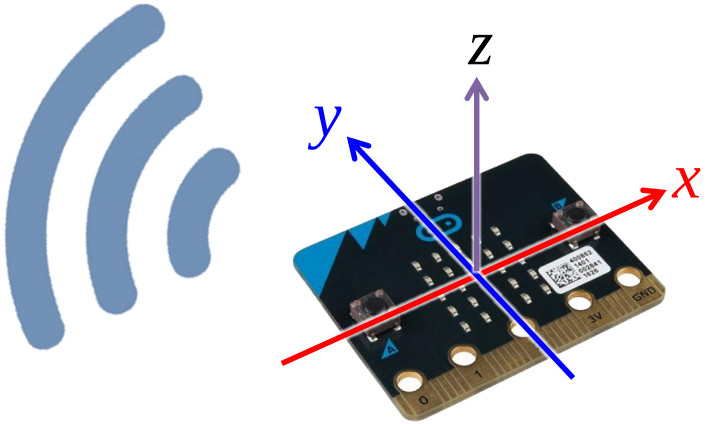
Rate and Ratio



S T E A M

Micro:bit Technology: Data Logging





Understanding of Speed and its Graphs

1 Rate and Ratio

Rate is a quotient of two quantities of different kinds.

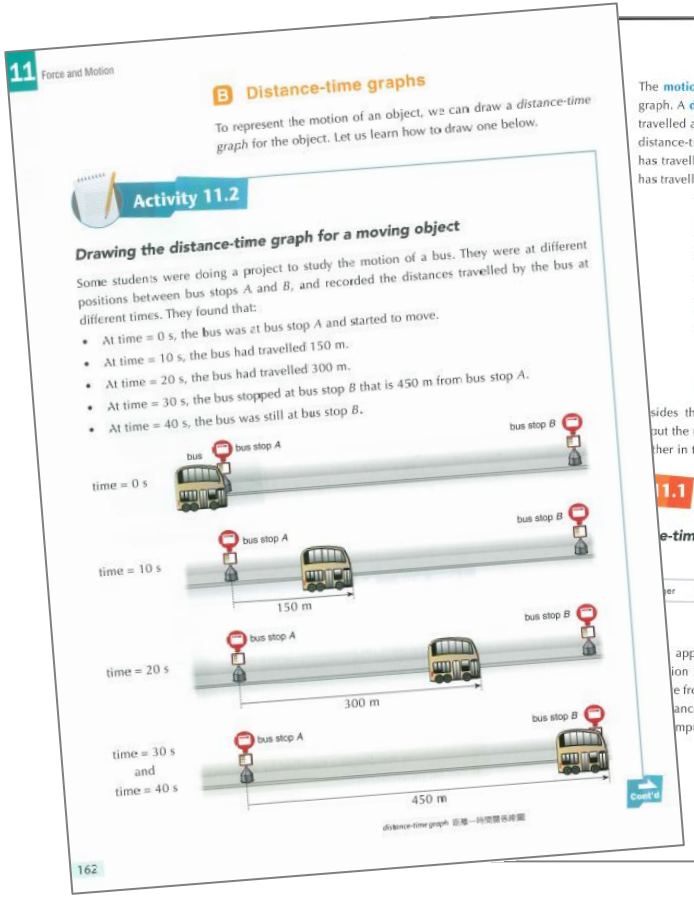
Speed is the distance travelled by a moving object per unit time.

$$\text{Speed} = \frac{\text{distance travelled}}{\text{time taken}}$$

Common units of speed include km/h and m/s.

e.g. If a car travels 200 km in 5 hours, then

$$\text{the speed of the car} = \frac{200\text{ km}}{5\text{ h}} = 40\text{ km/h}$$


11 Force and Motion

B Distance-time graphs

To represent the motion of an object, we can draw a *distance-time graph* for the object. Let us learn how to draw one below.

Activity 11.2

Drawing the distance-time graph for a moving object

Some students were doing a project to study the motion of a bus. They were at different positions between bus stops *A* and *B*, and recorded the distances travelled by the bus at different times. They found that:

- At time = 0 s, the bus was at bus stop *A* and started to move.
- At time = 10 s, the bus had travelled 150 m.
- At time = 20 s, the bus had travelled 300 m.
- At time = 30 s, the bus stopped at bus stop *B* that is 450 m from bus stop *A*.
- At time = 40 s, the bus was still at bus stop *B*.

Cont'd

distance-time graph 距離—時間關係圖

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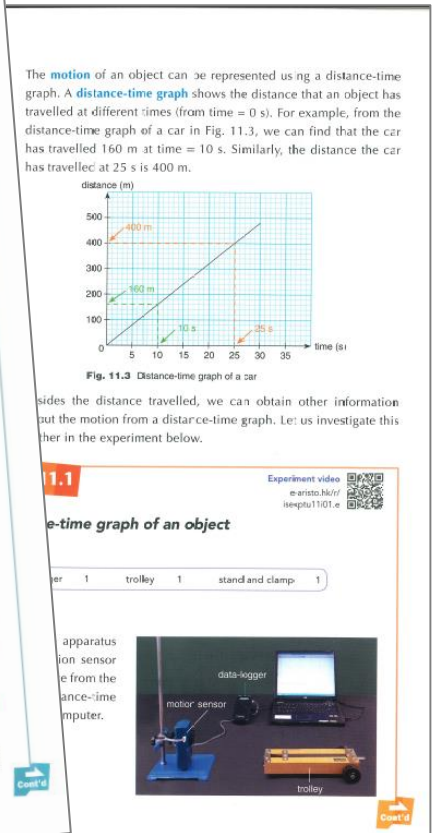

The motion of an object can be represented using a distance-time graph. A distance-time graph shows the distance that an object has travelled at different times (from time = 0 s). For example, from the distance-time graph of a car in Fig. 11.3, we can find that the car has travelled 160 m at time = 10 s. Similarly, the distance the car has travelled at 25 s is 400 m.

Fig. 11.3 Distance-time graph of a car

sides the distance travelled, we can obtain other information put the motion from a distance-time graph. Let us investigate this ther in the experiment below.

11.1

Experiment video
e-aristo.hk/r/
ise=ptu11i01.e

e-time graph of an object

er 1 trolley 1 stand and clamp 1

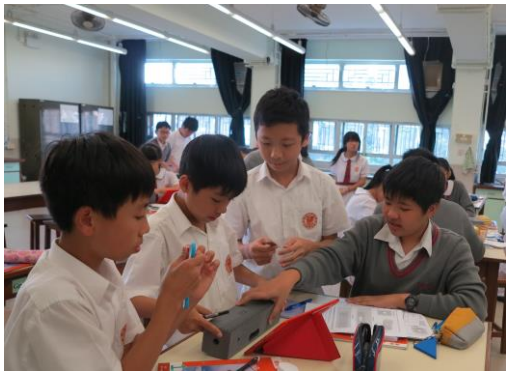
apparatus
ion sensor
e from the
ance-time
mputer.

Cont'd

Direct instruction

The use of instruction on the targeted concepts followed by or coupled with the use of well-designed worked examples to illustrate and explain the targeted concepts.

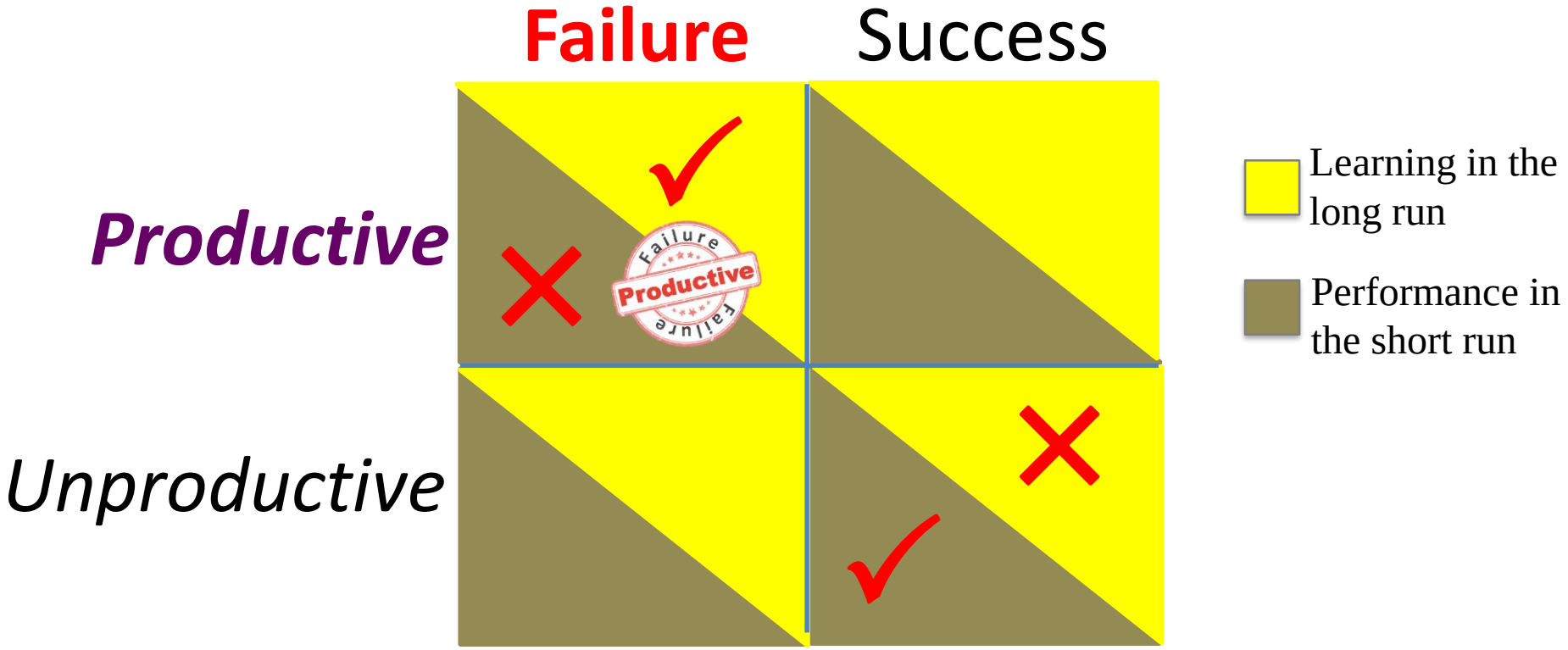
Productive Failure (PF)



A pedagogical design which affords the students the opportunities to generate *suboptimal* or *incorrect solutions* to a novel problem for preparing them to learn better from the subsequent instruction that followed.

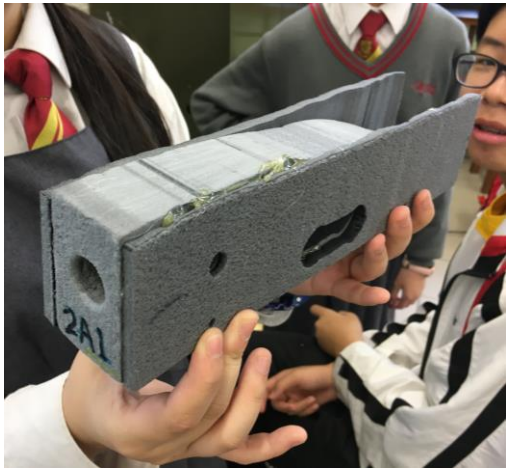
Kapur, M. (2016). Examining productive failure, productive success, unproductive failure, and unproductive success in learning. Educational Psychologist, 51(2), 289-299.

Kapar's Productive Failure



Kapur, M. (2016). Examining productive failure, productive success, unproductive failure, and unproductive success in learning. Educational Psychologist, 51(2), 289-299.

Chances to Failure

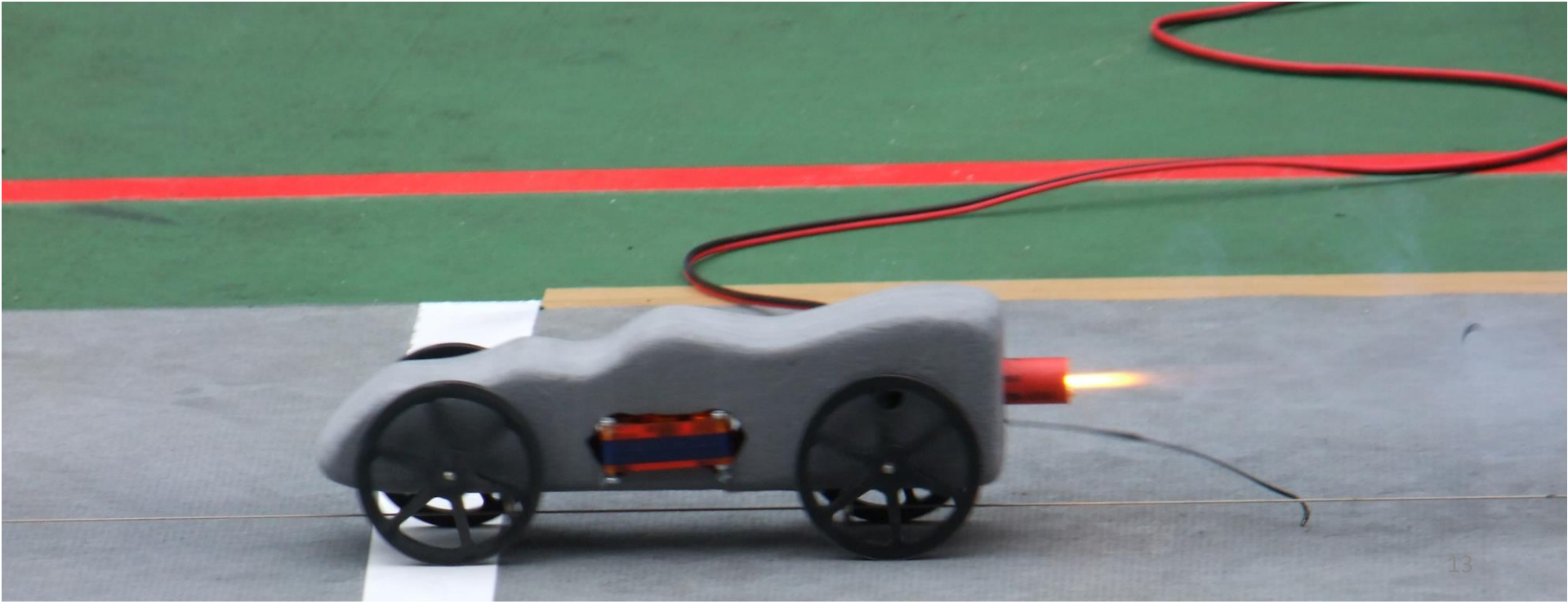


"By failure, I simply mean that students are rarely able to solve the problems and discover the canonical solutions by themselves." (Kapur, 2013)

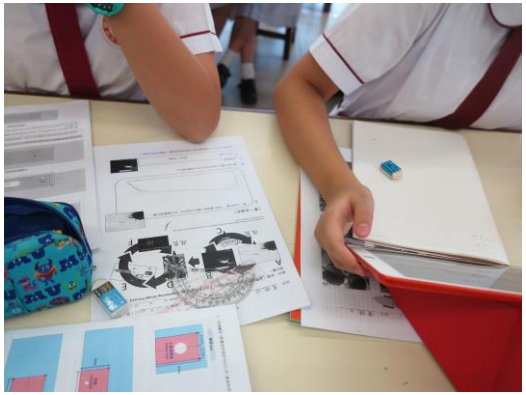
Kapur, M. (2013). Comparing learning from productive failure and vicarious failure. The Journal of the Learning Sciences, 23(4), 651–677.

A novel problem

Design a *streamline* rocket car for the competition in which the speed is competed.



Learning Phases



Phase 2: Instruction
Consolidation and knowledge assembly

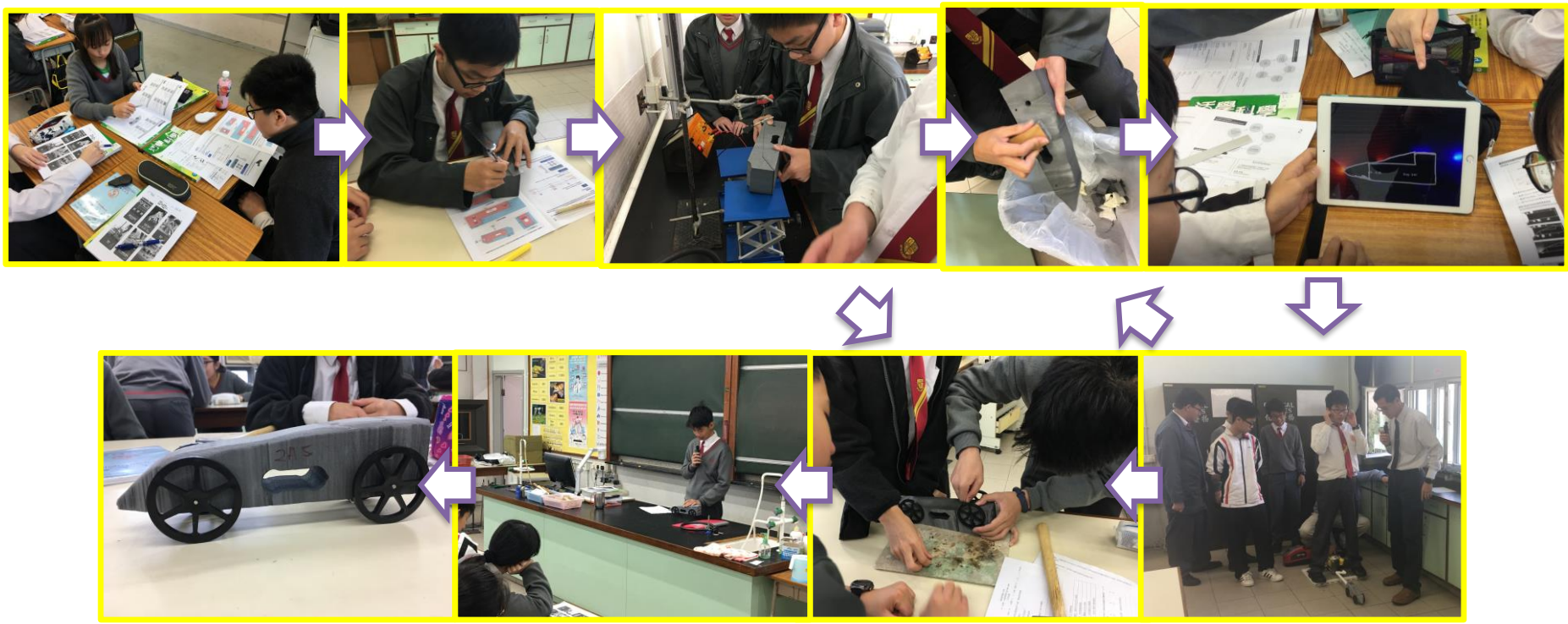
Phase 1: Problem-solving
Generate and explore representations and solution methods

Kapur, M., & Bielaczyc, K. (2012). Designing for productive failure. Journal of the Learning Sciences, 21(1), 45-83.

Lessons design

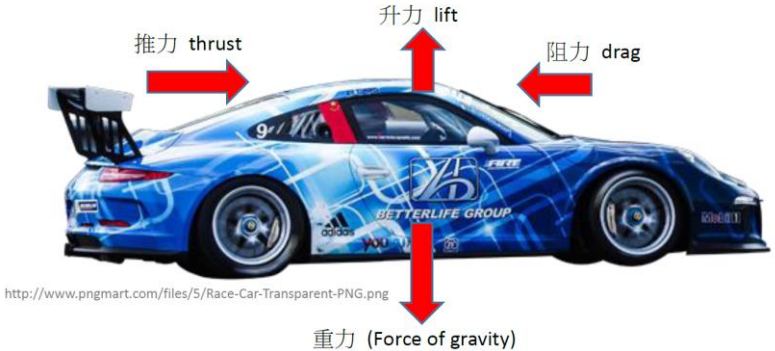
Class / Lesson	1	2	3	4	5	6
Treatment Class	Pre-test	 			Consolidation and refinement 	Post-test
Comparison Class						

Engineering design process



Pre-post Test

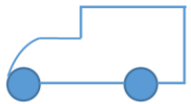
1. 以下哪一對力作用在跑車上所產生的不平衡力 (unbalanced forces)，可令跑車行駛？



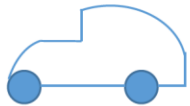
A. 升力及阻力
B. 推力及升力
C. 推力及阻力
D. 重力及推力

5. 以下哪種汽車設計的空氣阻力最少？

A.



B.



C.

D.

Pre-post analysis

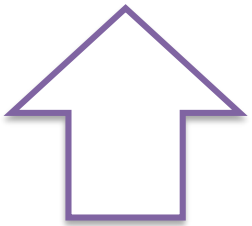
Post – Pre	*t*	df	*p*
Treatment	4.442	31	< .001
Comparison	2.778	32	.009

Snapshot

Knowledge Integration Categories

Knowledge Integration Categories	*Score*	*Response Characteristics*
Systemic link Students have a systemic understanding of science concepts.	Not applied	Compare similarities and differences between contexts, and apply concepts relevant to each context.
Complex link Students understand how more than two science concepts interact in a given context.	5	Elaborate two or more scientifically valid links among ideas relevant to a given context.
Full link Students understand how two scientific concepts interact in a given context.	4	Elaborate a scientifically valid link between two ideas relevant to a given context.
Partial link Students recognize potential connections between concepts but cannot elaborate the nature of the connections specific to a given context.	3	Indicate a link between relevant ideas but do not fully elaborate the link in a given context.
No link Students have non-normative ideas and/or make scientifically invalid links in a given context.	2	Make links between relevant and irrelevant ideas. Have non-normative ideas.
Off task Students make statements about non-scientific situations.	1	
No answer	0	Blank

L Complex link

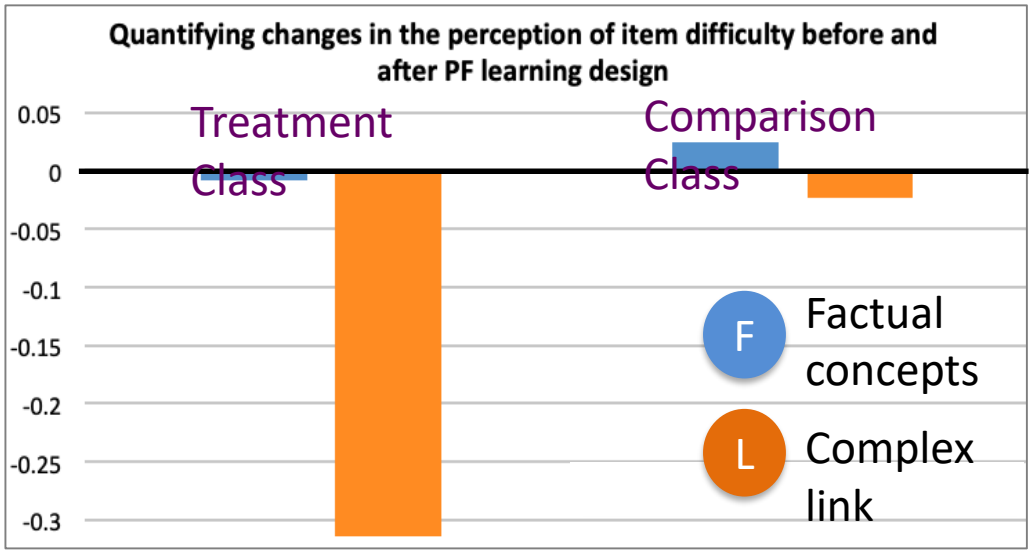


F Factual concepts (No link)

Liu, O.L., Lee, H.S., Hofstetter, C. & Linn, M.S. (2008). Assessing knowledge integration in Science: Construct, measures, and evidence. Educational Assessment, 13(1), 33-55.

IRT analysis

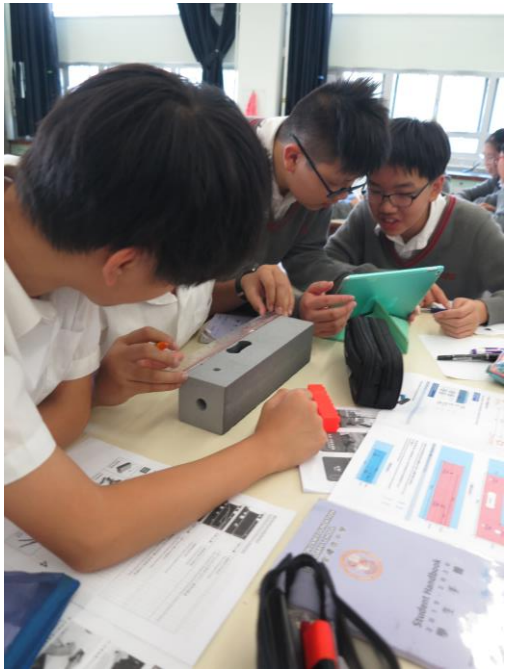
Item Response Theory (IRT) is applied to test whether PF learning design might change students' perception in item difficulty in Science subject.



Conclusion

PF pedagogical design can help the struggling learners to acquire scientific concepts and to form complex link between them.

Further Discussion



How are basic facts retrieved for further integration to form complex links?

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