興趣導向式的資訊 / AI教育

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政策對於教育影響立竿見影

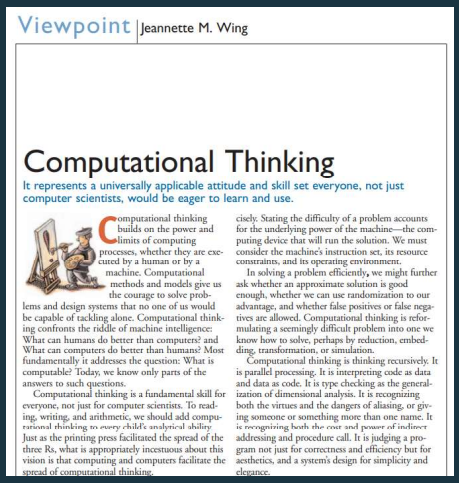
新課綱與大學入學

- 素養導向
- 資訊科技正式納入課綱
- 自主學習
- 學習歷程

核心素養的內涵（三面九項）

國際運算思維與AI教育的國際浪潮

運算思維 (Computational Thinking)



Viewpoint | Jeannette M. Wing

Computational Thinking

It represents a universally applicable attitude and skill set everyone, not just computer scientists, would be eager to learn and use.

Computational thinking builds on the power and limits of computing processes, whether they are executed by a human or by a machine. Computational methods and models give us the courage to solve problems and design systems that no one of us would be capable of tackling alone. Computational thinking confronts the riddle of machine intelligence: What can humans do better than computers? and What can computers do better than humans? Most fundamentally it addresses the question: What is computable? Today, we know only parts of the answers to such questions.

Computational thinking is a fundamental skill for everyone, not just for computer scientists. To reading, writing, and arithmetic, we should add computational thinking to every child's analytical ability. Just as the printing press facilitated the spread of the three Rs, what is appropriately incestuous about this vision is that computing and computers facilitate the spread of computational thinking.

cisely. Stating the difficulty of a problem accounts for the underlying power of the machine—the computing device that will run the solution. We must consider the machine's instruction set, its resource constraints, and its operating environment.

In solving a problem efficiently, we might further ask whether an approximate solution is good enough, whether we can use randomization to our advantage, and whether false positives or false negatives are allowed. Computational thinking is reformulating a seemingly difficult problem into one we know how to solve, perhaps by reduction, embedding, transformation, or simulation.

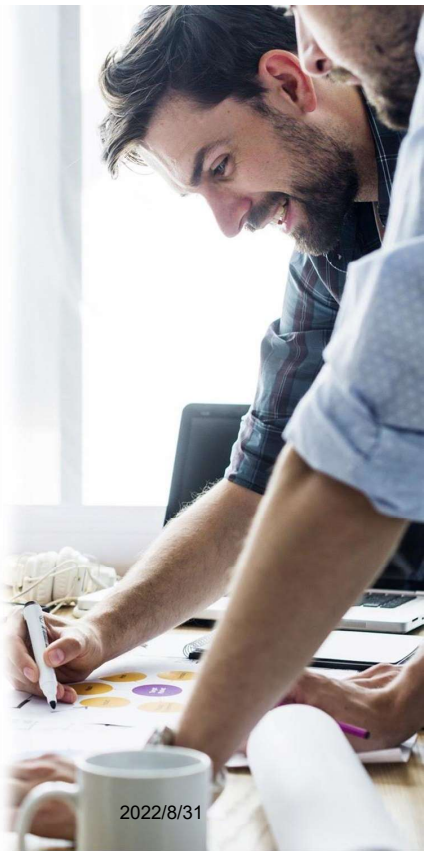
Computational thinking is thinking recursively. It is parallel processing. It is interpreting code as data and data as code. It is type checking as the generalization of dimensional analysis. It is recognizing both the virtues and the dangers of aliasing, or giving someone or something more than one name. It is recognizing both the cost and power of indirect addressing and procedure call. It is judging a program not just for correctness and efficiency but for aesthetics, and a system's design for simplicity and elegance.

“藉由電腦科學的基礎理論來了解人類行為、解決問題、設計系統”

– Jannette M. Wing

運算思維 (Computational Thinking)

- 抽象化
- 問題分解
- 遞迴思考
- 問題降階與轉換
- 錯誤預防與保護
- 經驗推理



108課綱的資訊教育

- 國中安排每週至少一個小時(或隔學期每週兩小時)
- 高中安排每週兩個小時的資訊課程
  - 內容分為「運算思維」與「設計思考」:「演算法」、「程式設計」、「系統平台」、「資料表示、處理及分析」、「資訊科技應用」、「資訊科技與人類社會」等。

108課綱的資訊教育

- 在人工智慧方面，新課綱並沒有特別的著墨

- 教材開發
  - 國小：著重體驗或以生活經驗。
  - 國中：機器學習的演算概念，包括決策樹、線性回歸、KNN、K-means分群等概念。
  - 高中：包括資料探勘技術(關聯法則、序列探勘)、監督式與非監督式的機器學習方法、增強式學習、與深度學習也有所著墨。

韓國 – 資訊教育

- 2015年開始新的資訊教育課程
  - 小學包含17小時的資訊課程的最低時數
  - 中學生的必修課程，每位學生必須修完至少34小時的資訊課程
  - 內容方面：與台灣的方向是相似的，資訊並非一單獨的技能，而是能夠在各領域有效並有創意的解決問題

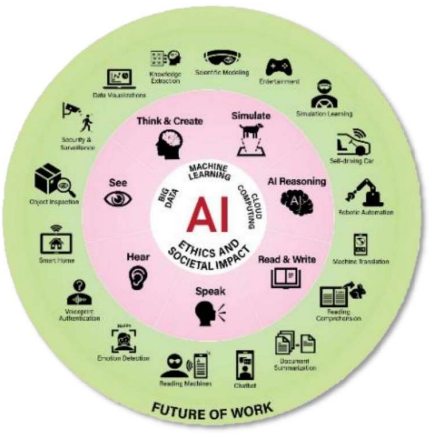
So, H. J., Jong, M. S. Y., & Liu, C. C. (2020). Computational Thinking Education in the Asian Pacific Region. The Asia-Pacific Education Researcher, 29, 1–8.

韓國 – AI

- 到2021年提供兩門選修課程「AI基礎」與「AI數學」在全國高中課程中開設
- 預計到2025年，全國K-12課程將正式納入AI教育課程。
  - 國小課程：認識AI、AI和資料、AI演算法、AI實作，和AI與社會等
  - 國中課程：使用AI的概念來解決問題與使用AI軟體來解決真實問題
  - 高中：第一年資訊課程(必修)，第二年與第三年選修不同AI相關的課程，三年總共必須修26學分。
- 前瞻的做法：預計從其師培管道在2024年前訓練5,000名AI相關的教師

香港

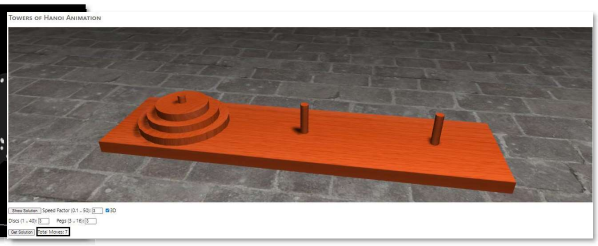
- 目前尚未有正式的AI課程指引，在校本STEM、ICT課程中逐步加入AI課題
- 香港賽馬會支助推動課程發展計畫AI4Furture
- 學生自我感知AI的能力、自信心、準備度與自我相關性



Chiu, T. K., Meng, H., Chai, C. S., King, I., Wong, S., & Yam, Y. (2021). Creation and Evaluation of a Pretertiary Artificial Intelligence (AI) Curriculum. IEEE Transactions on Education.

運算思維與AI教育的目標

樣式與程序



圖片取自 https://www.toptal.com/developers/sorting-algorithms

http://towersofhanoi.info/Animate.aspx

變局

需求

IEEE Spectrum

在複雜的社會演化中(變局)，

日復一日更新自己，察覺並創造新的(需求)，

分析其中複雜的關係與過程(程序與樣式)，

解決所遭遇的困境(意外)，

以找出可行與合理的解方

運算思維與人工智慧教育的內涵

運算思維與人工智慧教育的內涵

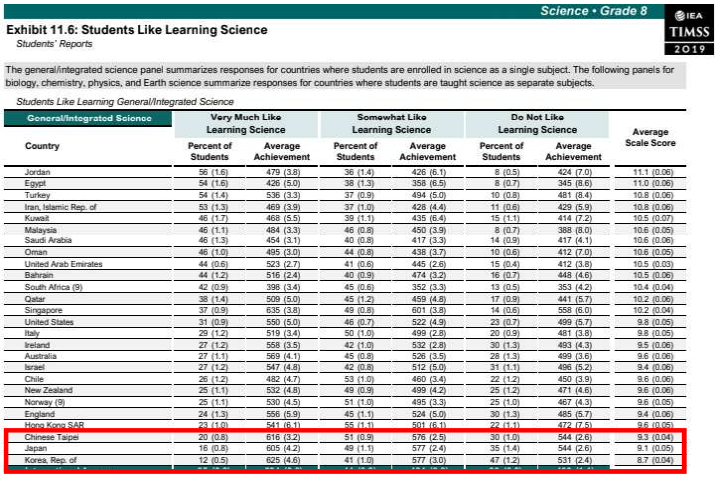
- **運算概念**: 抽象化、演算、遞迴、問題分解與轉換、樣式識別等
- **運算實務**: 軟體規劃、發展、測試評估、與除錯等
- **AI概念**：樣式識別與機器學習概念 (模型訓練、模型測試、模型應用)等
- **AI技術**：群集分析技術、分類技術、增強式學習技術等
- **AI應用**：應用現有AI工具於生活上應用 (語音、圖形、語言、數據)
- **AI社會**： AI的正向與可能負面的影響(倫理、法律、與經濟等議題)

運算思維與AI教育的潛在隱憂

一旦將目標納入必修科目，我們的教育體制就會自然地著重於學生的學習成就，也因此會格外注重學習成績。

能力與信心的矛盾現象

- 另一國際評比 TIMSS 2019
  - 八年級科學興趣為26個國家中倒數第3名
  - 八年級科學信心為26個國家中倒數第3名 (資料來源：https://timss2019.org/reports/)



Science • Grade 8

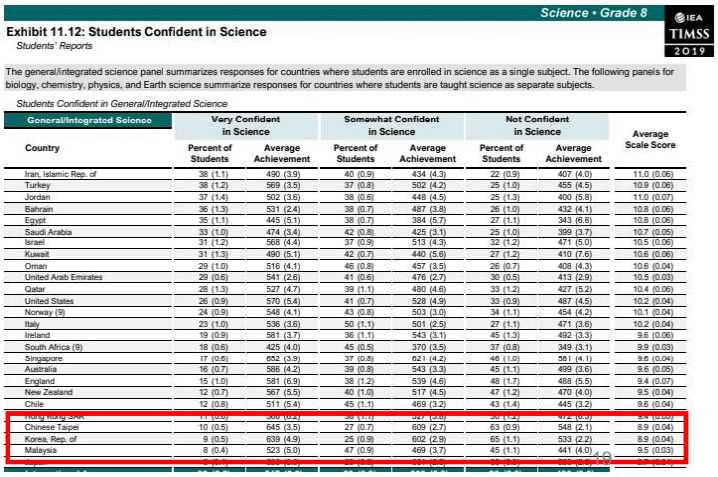
Exhibit 11.6: Students Like Learning Science

Students' Reports

The general/integrated science panel summarizes responses for countries where students are enrolled in science as a single subject. The following panels for biology, chemistry, physics, and Earth science summarize responses for countries where students are taught science as separate subjects.

Students Like Learning General/Integrated Science

General/Integrated Science	Very Much Like Learning Science		Somewhat Like Learning Science		Do Not Like Learning Science		Average Scale Score
Country	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	
Jordan	56 (1.6)	479 (3.8)	36 (1.4)	426 (6.1)	8 (0.5)	424 (7.0)	11.1 (0.06)
Egypt	54 (1.6)	426 (5.0)	38 (1.3)	358 (6.5)	8 (0.7)	345 (8.6)	11.0 (0.06)
Turkey	54 (1.4)	536 (3.3)	37 (0.9)	494 (5.0)	10 (0.8)	481 (8.4)	10.8 (0.06)
Iran, Islamic Rep. of	53 (1.3)	469 (3.9)	37 (1.0)	426 (4.4)	11 (0.6)	429 (5.9)	10.8 (0.06)
Kuwait	46 (1.7)	468 (5.5)	39 (1.1)	435 (6.4)	15 (1.1)	414 (7.2)	10.5 (0.07)
Malaysia	46 (1.1)	484 (3.3)	46 (0.8)	450 (3.9)	8 (0.7)	388 (8.0)	10.6 (0.05)
Saudi Arabia	46 (1.3)	454 (3.1)	40 (0.8)	417 (3.3)	14 (0.9)	417 (4.1)	10.6 (0.06)
Oman	46 (1.0)	495 (3.0)	44 (0.8)	438 (3.7)	10 (0.6)	412 (7.0)	10.6 (0.05)
United Arab Emirates	44 (0.6)	523 (2.7)	41 (0.6)	445 (2.6)	15 (0.4)	412 (3.8)	10.5 (0.03)
Bahrain	44 (1.2)	516 (2.4)	40 (0.9)	474 (3.2)	16 (0.7)	448 (4.6)	10.5 (0.06)
South Africa (9)	42 (0.9)	398 (3.4)	45 (0.6)	352 (3.3)	13 (0.5)	353 (4.2)	10.4 (0.04)
Qatar	38 (1.4)	509 (5.0)	45 (1.2)	459 (4.8)	17 (0.9)	441 (5.7)	10.2 (0.06)
Singapore	37 (0.9)	635 (3.8)	49 (0.8)	601 (3.8)	14 (0.6)	558 (6.0)	10.2 (0.04)
United States	31 (0.9)	550 (5.0)	46 (0.7)	522 (4.9)	23 (0.7)	499 (5.7)	9.8 (0.05)
Italy	29 (1.2)	519 (3.4)	50 (1.0)	499 (2.8)	20 (0.9)	481 (3.8)	9.8 (0.05)
Ireland	27 (1.2)	558 (3.5)	42 (1.0)	532 (2.8)	30 (1.3)	493 (4.3)	9.5 (0.06)
Australia	27 (1.1)	569 (4.1)	45 (0.8)	526 (3.5)	28 (1.3)	499 (3.6)	9.6 (0.06)
Israel	27 (1.2)	547 (4.8)	42 (0.8)	512 (5.0)	31 (1.1)	496 (5.2)	9.4 (0.06)
Chile	26 (1.2)	482 (4.7)	53 (1.0)	460 (3.4)	22 (1.2)	450 (3.9)	9.6 (0.06)
New Zealand	25 (1.1)	532 (4.8)	49 (0.9)	499 (4.2)	25 (1.2)	471 (4.6)	9.6 (0.06)
Norway (9)	25 (1.1)	530 (4.5)	51 (1.0)	495 (3.3)	25 (1.0)	467 (4.3)	9.6 (0.05)
England	24 (1.3)	556 (5.9)	45 (1.1)	524 (5.0)	30 (1.3)	485 (5.7)	9.4 (0.06)
Hong Kong SAR	23 (1.0)	541 (6.1)	55 (1.1)	501 (6.1)	22 (1.1)	472 (7.5)	9.6 (0.05)
Chinese Taipei	20 (0.8)	616 (3.2)	51 (0.9)	576 (2.5)	30 (1.0)	544 (2.6)	9.3 (0.04)
Japan	16 (0.8)	605 (4.2)	49 (1.1)	577 (2.4)	35 (1.4)	544 (2.6)	9.1 (0.05)
Korea, Rep. of	12 (0.5)	625 (4.6)	41 (1.0)	577 (3.0)	47 (1.2)	531 (2.4)	8.7 (0.04)



Science • Grade 8

Exhibit 11.12: Students Confident in Science

Students' Reports

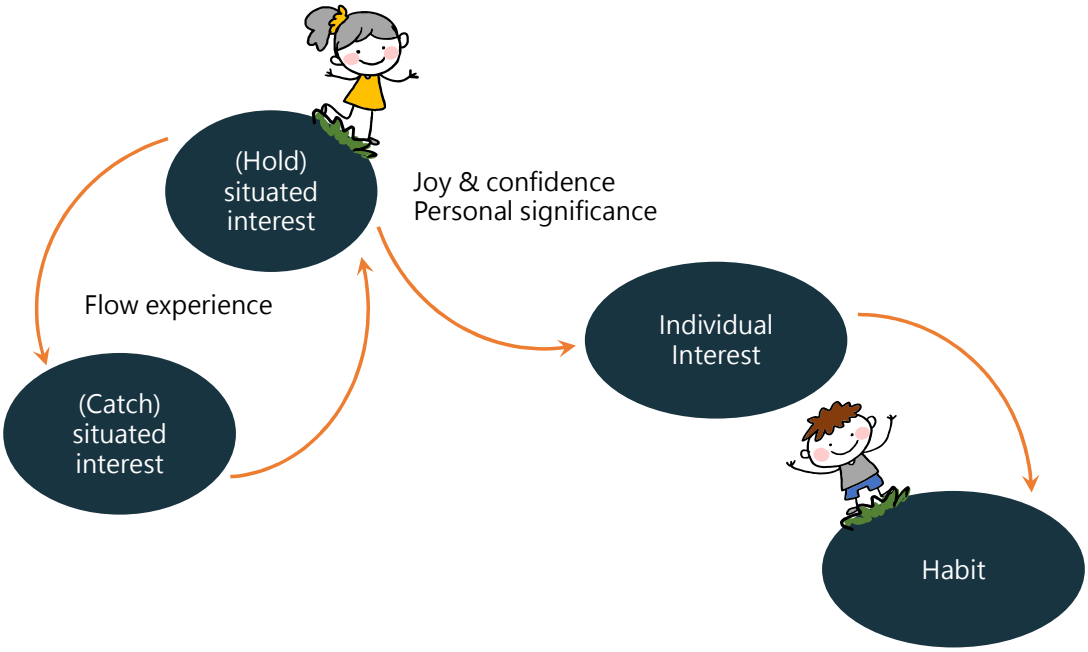
The general/integrated science panel summarizes responses for countries where students are enrolled in science as a single subject. The following panels for biology, chemistry, physics, and Earth science summarize responses for countries where students are taught science as separate subjects.

Students Confident in General/Integrated Science

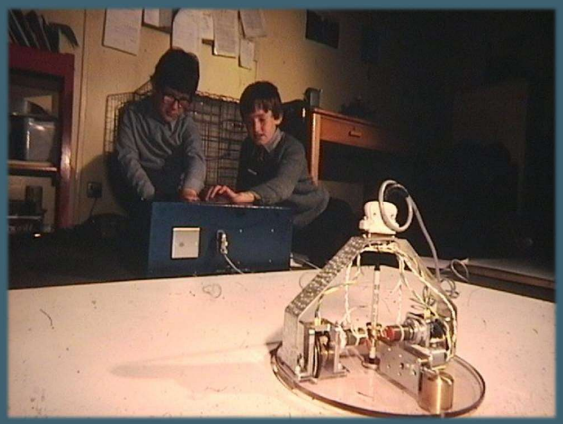
General/Integrated Science	Very Confident in Science		Somewhat Confident in Science		Not Confident in Science		Average Scale Score
Country	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	
Iran, Islamic Rep. of	38 (1.1)	490 (3.9)	40 (0.9)	434 (4.3)	22 (0.9)	407 (4.0)	11.0 (0.06)
Turkey	38 (1.2)	569 (3.5)	37 (0.8)	502 (4.2)	25 (1.0)	455 (4.5)	10.9 (0.06)
Jordan	37 (1.4)	502 (3.6)	38 (0.6)	448 (4.5)	25 (1.3)	400 (5.8)	11.0 (0.07)
Bahrain	36 (1.3)	531 (2.4)	38 (0.7)	487 (3.8)	26 (1.0)	432 (4.1)	10.8 (0.06)
Egypt	35 (1.1)	445 (5.1)	38 (0.7)	384 (5.7)	27 (1.1)	343 (6.8)	10.8 (0.06)
Saudi Arabia	33 (1.0)	474 (3.4)	42 (0.8)	425 (3.1)	25 (1.0)	399 (3.7)	10.7 (0.05)
Israel	31 (1.2)	568 (4.4)	37 (0.9)	513 (4.3)	32 (1.2)	471 (5.0)	10.5 (0.06)
Kuwait	31 (1.3)	490 (5.1)	42 (0.7)	440 (5.6)	27 (1.2)	410 (7.6)	10.6 (0.06)
Oman	29 (1.0)	516 (4.1)	46 (0.8)	457 (3.5)	26 (0.7)	408 (4.3)	10.6 (0.04)
United Arab Emirates	29 (0.6)	541 (2.6)	41 (0.6)	476 (2.7)	30 (0.5)	413 (2.9)	10.5 (0.03)
Qatar	28 (1.3)	527 (4.7)	39 (1.1)	480 (4.6)	33 (1.2)	427 (5.2)	10.4 (0.06)
United States	26 (0.9)	570 (5.4)	41 (0.7)	528 (4.9)	33 (0.9)	487 (4.5)	10.2 (0.04)
Norway (9)	24 (0.9)	548 (4.1)	43 (0.8)	503 (3.0)	34 (1.1)	454 (4.2)	10.1 (0.04)
Italy	23 (1.0)	536 (3.6)	50 (1.1)	501 (2.5)	27 (1.1)	471 (3.6)	10.2 (0.04)
Ireland	19 (0.9)	581 (3.7)	36 (1.1)	543 (3.1)	45 (1.3)	492 (3.3)	9.6 (0.06)
South Africa (9)	18 (0.6)	425 (4.0)	45 (0.5)	370 (3.5)	37 (0.8)	349 (3.1)	9.9 (0.03)
Singapore	17 (0.6)	652 (3.9)	37 (0.8)	621 (4.2)	46 (1.0)	581 (4.1)	9.6 (0.04)
Australia	16 (0.7)	586 (4.2)	39 (0.8)	543 (3.3)	45 (1.1)	499 (3.6)	9.6 (0.05)
England	15 (1.0)	581 (6.9)	38 (1.2)	539 (4.6)	48 (1.7)	488 (5.5)	9.4 (0.07)
New Zealand	12 (0.7)	567 (5.5)	40 (1.0)	517 (4.5)	47 (1.2)	470 (4.0)	9.5 (0.04)
Chile	12 (0.8)	511 (5.4)	45 (1.1)	469 (3.2)	43 (1.4)	445 (3.2)	9.6 (0.04)
Hong Kong SAR	11 (0.6)	596 (6.2)	35 (1.1)	527 (3.8)	53 (1.2)	472 (4.0)	9.4 (0.05)
Chinese Taipei	10 (0.5)	645 (3.5)	27 (0.7)	609 (2.7)	63 (0.9)	548 (2.1)	8.9 (0.04)
Korea, Rep. of	9 (0.5)	639 (4.9)	25 (0.9)	602 (2.9)	65 (1.1)	533 (2.2)	8.9 (0.04)
Malaysia	8 (0.4)	523 (5.0)	47 (0.9)	469 (3.7)	45 (1.1)	441 (4.0)	9.5 (0.03)
Japan	5 (0.4)	615 (6.5)	45 (0.7)	581 (3.3)	50 (1.0)	552 (3.5)	8.7 (0.04)

https://blog.scientix.eu/2018/04/science-education-with-inquiry-based-learning/

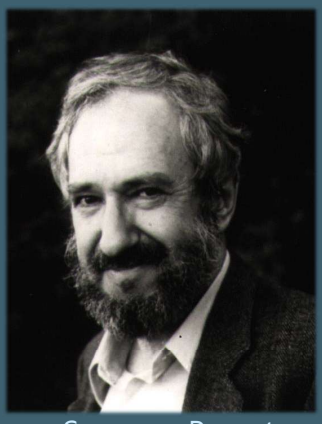
在興趣中培養學生運算思維與AI能力



以建造為目標激勵學生學習運算思維與AI



Logo in 1967



Seymour Papert

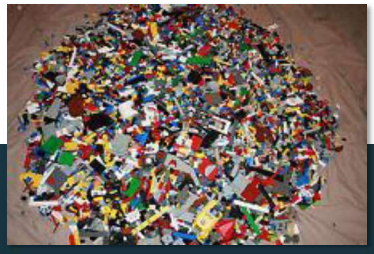
Constructionism：Learning “happens especially felicitously in a context where the learner is consciously engaged in constructing a public entity” (Harel & Papert, 1991)

Low threshold, High ceiling, Wide wall

- **Low threshold**：
  enabling novice students to easily participate in
- **High ceiling**：
  allowing students to work on increasingly complex products
- **Wide wall**：

  allowing students to build products based on personal interest

From Lego website

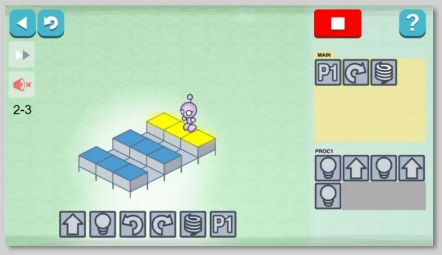


以建造為目標激勵學生學習運算思維與AI

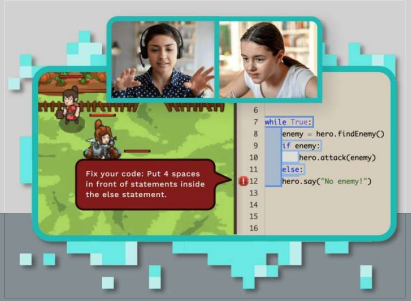
- 有許多專業軟體可使用
  - Weka、TensorFlow、Keras、Scikit-learn、H2O、rapidminer等比較複雜的軟體，而各廠商針對不同應用也推出不同的AI應用工具，例如微軟的Custom Speech Service、亞馬遜的AWS Rekognition等。
- 缺少K-12教學資源
  - 缺乏建構的AI學習軟體
  - 缺乏在AI的主題建構案例

遊戲情境吸引學生投入

CoSci.tw



LightBot



CodeCombat

Code.org

生活問題解決引起學生興趣

- 問題導向式的學習(problem-based learning)
  - 引導學生找出生活周遭的問題
  - 引導他們去使用電腦與AI來解決問題
- 學習的內容與學生的生活息息相關時，他們才真正有興趣有動機去學習這樣的內容

圖片來源
數位學習深耕計畫：西湖國小轉角遇到礙

建議

- 確立實施運算思維與AI教育的教育目標
  - K-12: 重在全民普遍AI認識的建立，而非在培養專業的AI技術開發人員
  - 由運算思維開始：AI概念、AI應用、AI相關倫理、AI技術
  - 建立應用AI的信心與興趣：遊戲 ➔ 建構 ➔ 技術

建議

- 實施分層分級，並提供選項讓學生依需求自主選擇
  - 國小：體驗遊戲吸引投入
  - 國中：著重邏輯與問題解決、解決生活問題
  - 高中：接觸程式語言以建造為目標培養興趣
  - 應能適性適才發展: 有些學生可能所需的是在其生活領域中應用相關工具即可
  - 對於專業的AI技術發展有興趣，則可以選修相關技術的課程

建議

- 培訓資訊教師AI知能，充實運算思維與AI教案庫與案例庫
  - 老師對於AI相關的教學經驗仍甚缺乏
  - 開設相關教師專業發展課程
  - 老師缺乏AI應用教案庫
  - 提供老師資料集與適合學生的AI應用工具

建議

- 避免考試帶來反效果
  - 紙筆測驗限制學生的興趣
  - 實作評量透過動手做的作業更能帶動學生的學習興趣
  - 競賽活動刺激學生學習的動機