

教師如何因應「探究與實作」 課程-以美國推動 NGSS 實 作為例

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摘要

107 自然領綱草案揭示「探究與實作」課程的學習重點分為「探究學習內容」和「實作學習內容」兩部分。「探究學習內容」著重於科學探究歷程，可歸納為四個主要項目：發現問題、規劃與研究、論證與建模、表達與分享。「實作學習內容」為可實際進行操作的科學活動，例如：觀察與測量、資料蒐集與分析、歸納與解釋、論證與作結論。這八個學習重點與美國下一代科學教育標準 (Next Generation Science Standards, 簡稱 NGSS) 實作重點非常相似。本文以 NGSS 的實作架構為例，說明如何藉專書、工作坊課程來引導現職教師深入瞭解「探究與實作」課程的理念與目標。(內文詳附免費網路資源可供教師自學或教師社群共同備課使用。)

前言

107 自然領域課綱草案推出「探究與實作」課程，讓教學現場教師感到迷惘與憂心。雖然領綱草案附有大量建議教學示例，同時國教署專案委請各師培大學與科教中心開發示例並對現職教師加以培訓，諸多配套仍無法有效降低教師心中對課程施行的疑慮。在此特別整理美國推動實作課程的一些資料，供教師們參考，現職教師可藉教學社群共同備課來因應新課程的挑戰。

在 107 自然領域課綱研修過程中，曾參考美國下一代科學教育標準 (Next Generation Science Standards, 簡稱 NGSS) 的內容，兩者實作重點非常相似(見表 1)，以下就以 NGSS 實作架構來說明現職教師應如何來準備「探究與實作」課程。

表 1：探究與實作課程的學習重點

107 課綱	NGSS
提出並定義問題、建立發現問題、規劃與研究、論證與建模、表達與分享、觀察與測量、資料蒐集與分析、歸納與解釋、論證與作結論。	提出並定義問題、建立和使用模型、規劃並進行探索、分析和解釋數據、使用數學和計算的思維、建構說明和設計解答、從證據進行論證、獲取評價和交流資訊

以下介紹分為專書與工作坊課程兩部分來說明，架構如下(見表 2)：

表 2：說明內容與 107 自然領綱對應

NGSS 專書 工作坊課程	107 自然領綱內涵
(1)NSTA 美國科學教師聯盟	實作重點說明 與 k-12 各學習階段 差異
(2)CRS 科學社群資源中心	8 個重點的逐項說明 (工作投影片及影片)
(3)The Physics Classroom 物理教室	8 個重點的活動設計

(一)專書

美國國家學術出版中心 (The National Academies Press, 簡稱 NAP) 針對下一個世代的科學教育標準，於 2012 年起出版了四本專書，依序為：

- (1) A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (2012)
- (2) Next Generation Science Standards: For States, By States (2013)

(3) Developing Assessments for the Next Generation Science Standards (2014)

(4) Guide to Implementing the Next Generation Science Standards (2015)

這四本書將整個 NGSS 從架構、內涵、評量和施行都做了完整的報告，可供我們在 107 課綱施行時參考。專書可自網站免費下載(參考網站 1)。

(二) 工作坊課程

首先，要瞭解實作的重點與 k-12 各階段差異，可參考美國科學教師聯盟(National Science Teachers Association, 簡稱 NSTA)網站，內容依 k-12 分四個階段呈現(如圖 1 所示，截取自參考網站 2)。

其次，在瞭解各階段的學習目標後，可參訪科學社群資源(Community Resources for Science, 簡稱 CRS) 網站，點選工作坊的投影片或講解影片，可更深入瞭解八個實作教學重點(如圖 2 所示，截取自參考網站 3)。建議至少參考其中三個部份，NSTA webinar 提供的教師工作坊投影片、Engineering is Elementary 及 BOZEMANSCIENCE 提供的影片。

最後，再參訪物理教室(The Physics Classroom)網站，其中提供了大量的教學活動實例，讓教師熟悉每一個實作技能的操作。(如圖 3 所示，截取自參考網站 4)

結語

教師在走訪這些網站之後，依建議方式閱讀與實作，應可深入瞭解「探究與實作」課程的理念與目標。在正式課程上路前，輔以各大學的專業培訓，必定能有足夠的專業素養達成課程目標。

Asking Questions and Defining Problems			
A practice of science is to ask and refine questions that lead to descriptions and explanations of how the natural and designed world works and which can be empirically tested.			
Primary School (K-2)	Elementary School (3-5)	Middle School (6-8)	High School (9-12)
Asking questions and defining problems in K-2 builds on prior experiences and progresses to simple descriptive questions.	Asking questions and defining problems in grades 3-5 builds from grades K-2 experiences and progresses to specifying qualitative relationships.	Asking questions and defining problems in grades 6-8 builds from grades K-5 experiences and progresses to specifying relationships between variables and clarifying arguments and models.	Asking questions and defining problems in 9-12 builds on grades K-8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.
<ul style="list-style-type: none"> Ask questions based on observations to find more information about the natural and/or designed worlds. Ask and/or identify questions that can be answered by an investigation. Define a simple problem that can be solved through the development of a new or improved object or tool. 	<ul style="list-style-type: none"> Ask questions about what would happen if a variable is changed. Identify scientific (testable) and non-scientific (non-testable) questions. Ask questions that can be investigated and predict measurable outcomes based on patterns such as cause and effect relationships. Use prior knowledge to describe. 	<ul style="list-style-type: none"> Ask questions that require sufficient and appropriate empirical evidence to answer. Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information. Ask questions to identify and/or 	<ul style="list-style-type: none"> Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information. Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.

(圖 1)

General Resources for Science and Engineering Practices	
1. Asking Questions (for science) and Defining Problems (for engineering)	<ul style="list-style-type: none"> Understanding Science – The Real Process of Science BOZEMANSCIENCE video on Asking Questions & Defining Problems The National Engineers Week website has a collection of engineering challenges for students that have predefined problems for students Engineering is Elementary - video snippets of the practices in the classroom NSTA webinar - archived - on Asking Questions and Defining Problems NSTA - Grade Level Progression
2. Developing and Using Models	
3. Planning and Carrying Out Investigations	
4. Analyzing and Interpreting Data	
5. Using Mathematics and Computational Thinking	
6. Constructing Explanations (for science) and Designing Solutions (for engineering)	
7. Engaging in Argument from Evidence	
8. Obtaining, Evaluating, and Communicating Information	

(圖 2)

Science and Engineering Practices	
Students' expression of their understanding of the Disciplinary Core Ideas cannot be done apart from the exercising of a variety of scientific and engineering practices. The practices emphasize the importance of students investigating the natural world through scientific inquiry and solving meaningful problems through engineering design. The eight Science and Engineering Practices identified by the Next Generation Science Standards are identified below. Click on the links to view activities that target each of these Science and Engineering Standards.	
Practice 1: Asking questions (for science) and defining problems (for engineering)	Activity 1: Egg Drop
Practice 2: Developing and using models	Activity 1: Rocket Sledder
	Activity 2: Skydiving
	Activity 3: Coffee Filter Physics
	Activity 4: Up and Down
	Activity 5: Marshmallow Launcher
	Activity 6: Inelastic Collisions
	Activity 7: Elastic Collisions
	Activity 8: Bat-Ball Collision
	Activity 9: Roller Coaster Energy

(圖 3)

參考網站

[1]NAP

<http://www.nap.edu/search/?term=ngss>

[2]NSTA

<http://ngss.nsta.org/Practices.aspx?id=1>

[3]CRS

<http://www.crsscience.org/educators/practices>

[4] The Physics Classroom

<http://www.physicsclassroom.com/NGSS-Corner/The-Practices>

本文改寫自 2016.5.21 2016 高瞻計畫教師工作坊「科教新視野」演講內容。