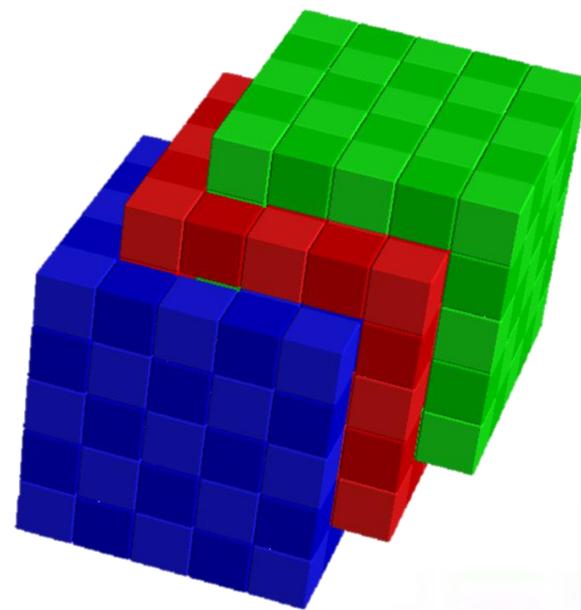


多方塊積木和組木之探索

組員：徐丙忠、林承俊、邱嵩槐、溫成鐘、黃虹菱



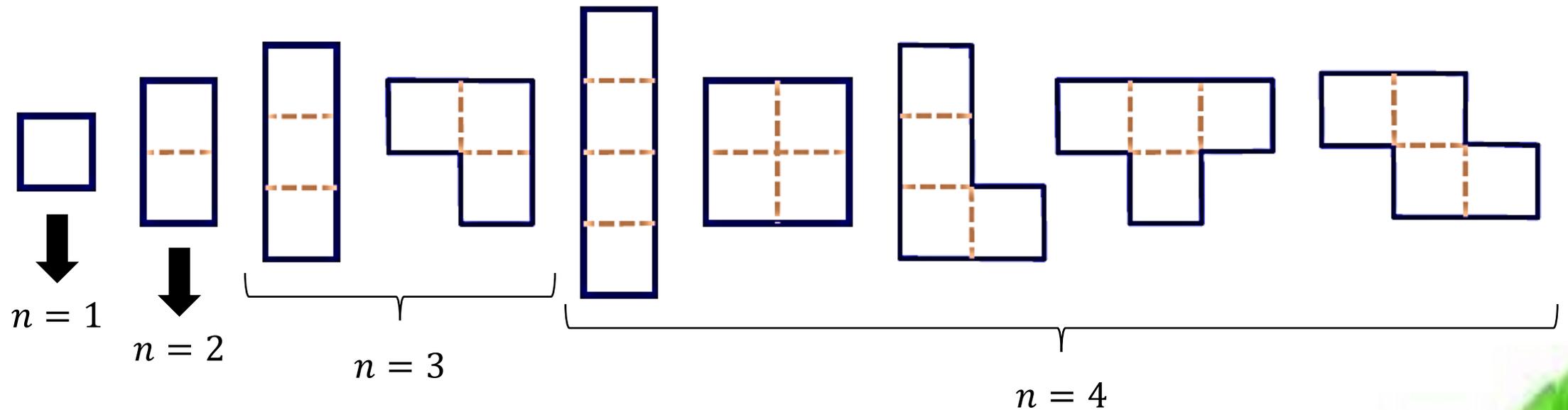
【大綱】

- 一、多方塊積木和組木之介紹
- 二、介紹Burrtools和操作方式
- 三、Burrtools實際操作應用
- 四、著名例子介紹&延伸探究
- 五、結語

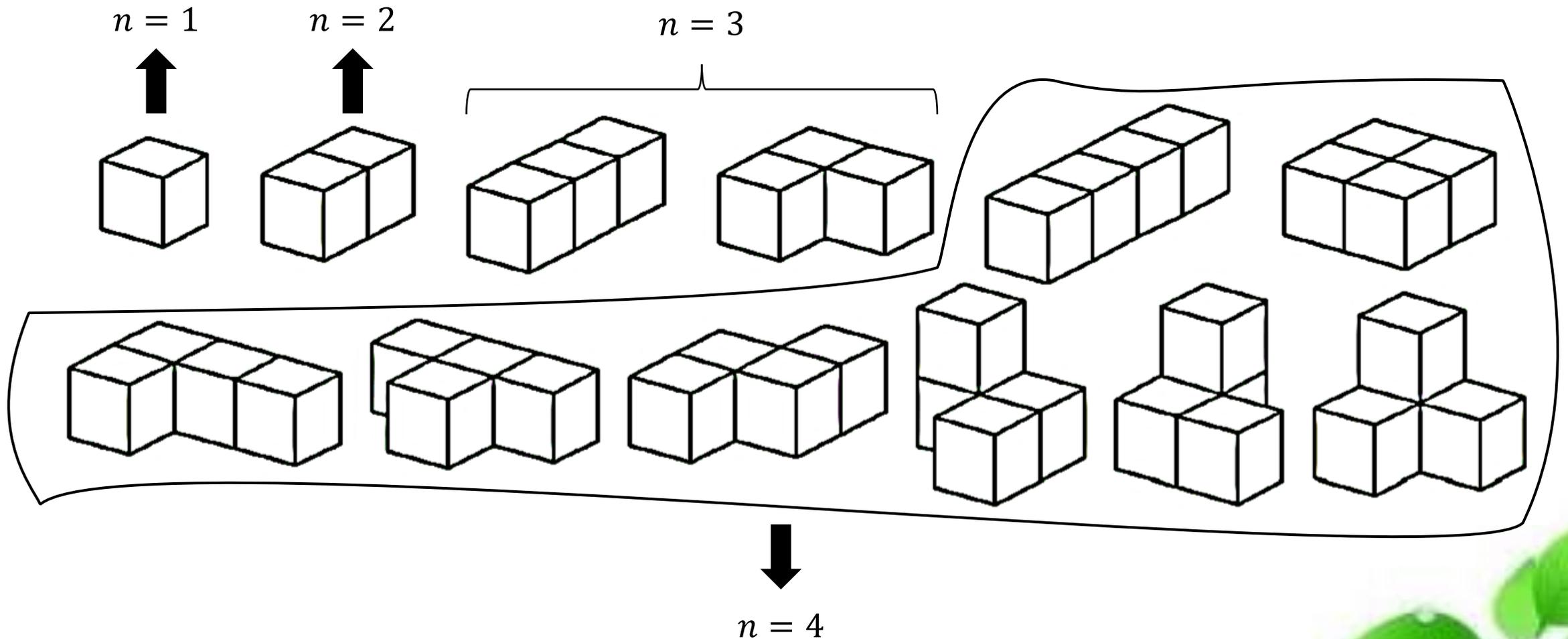


一、多方塊積木和組木之介紹

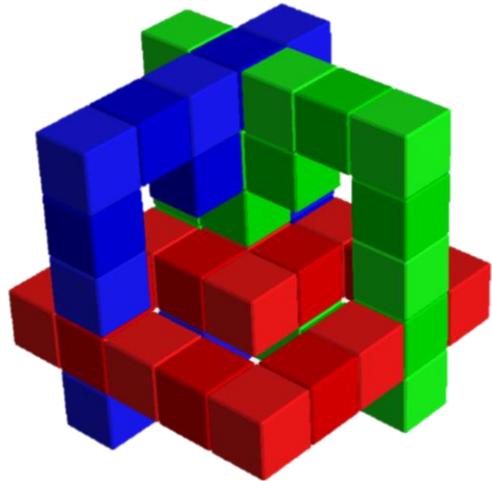
- ◆ 多方塊其實就是將雙方塊 (Domino) 的概念推廣，將 n 個邊長相等的正方形相連在一起，形成所謂 n -方塊 (n -omino)
- ◆ 以 $n \leq 4$ 的 n -方塊來為例，以下9個形狀都可以被稱為 n -方塊：



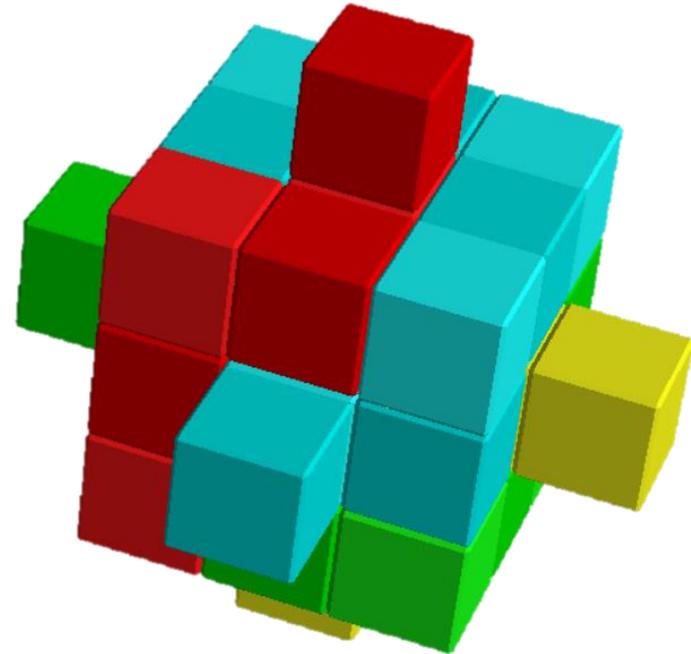
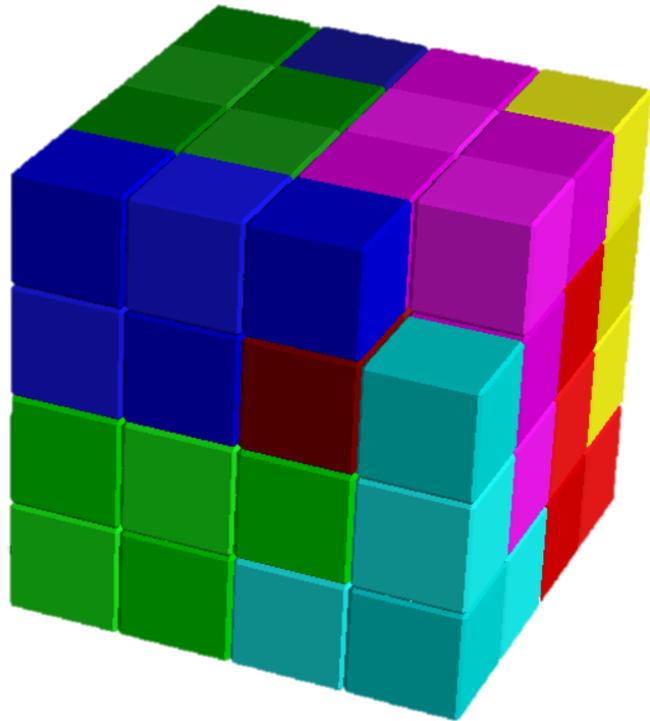
◆ 將多方塊在平面上的概念藉由立體化擴充到三維空間，形成多個正方體的相連。同理，考慮 $n \leq 4$ 時，可以構成以下12種圖形：



- ◆ 組木 (Interlock puzzles) 類的益智玩具與積木類的益智玩具，最大的差別在於「組木」玩具一旦完成組裝後，往往只有一個角度或是一個角度、一組零件可以被拆解。例如早期源自於建築接榫技術的「三榫組木 (3 pieces burr)」、「六榫組木 (6 pieces burr)」、「魯班鎖」、「孔明鎖」...等，且因為早期組木的設計趨勢朝向「更多榫件」或「多面體化」。因此大部分的組木都有更加絢麗的外表及更高的難度

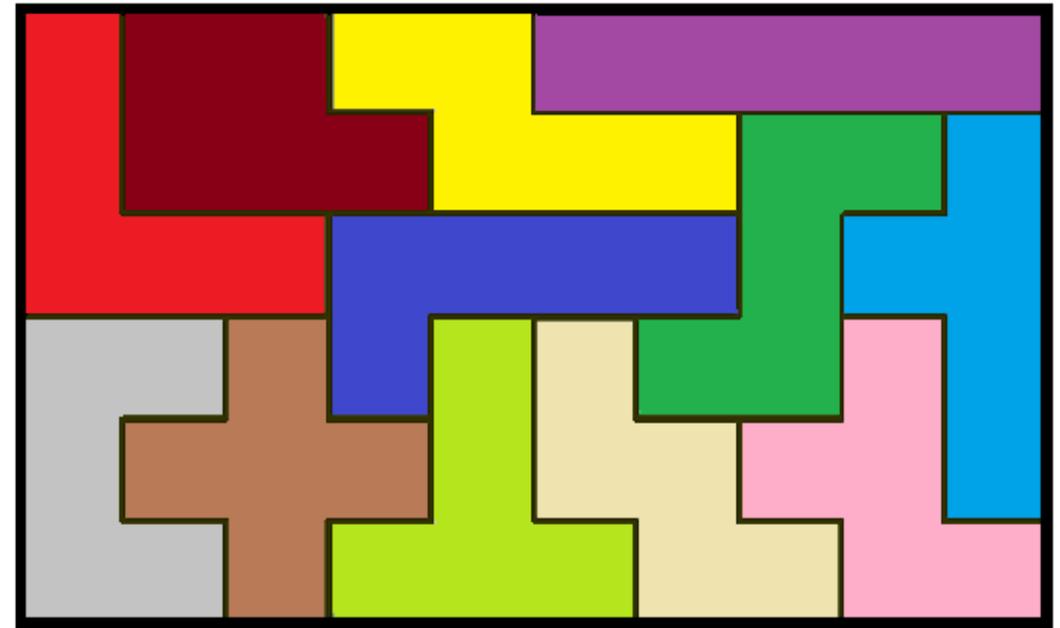


- ◆ 積木 (Put-together puzzle) 類的益智玩具，就是要將所有的玩具組件給堆疊、排列成為「特定的形體」，或是放入特定的容器之中。而這也是益智玩具中歷史最悠久，數量最多的一個類別，同時也是我們生活中最常接觸到的玩具類型。

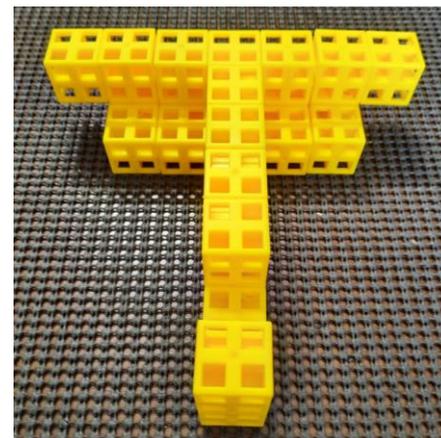
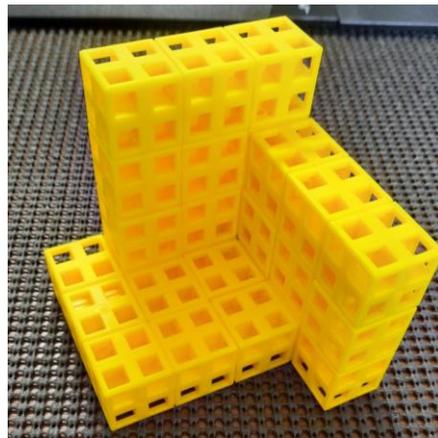
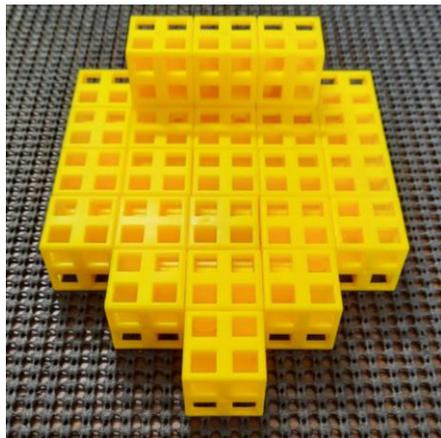
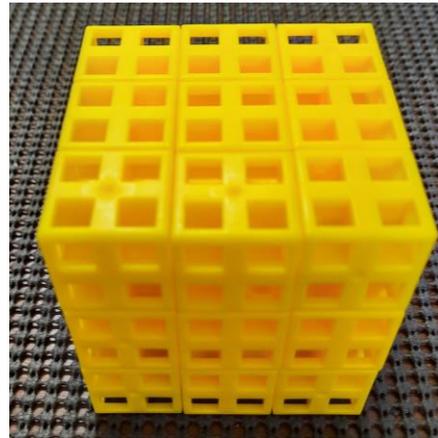


- ◆ 最早流行的多方塊積木為平面5 – 方塊組 (Pentomino set) 亦稱為「五方連」，有如下圖所示12種形狀，共有 $12 \times 5 = 60$ 平方單位，故可以拼成如下幾種形狀：

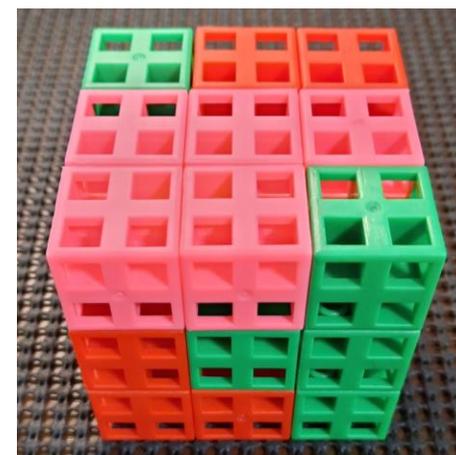
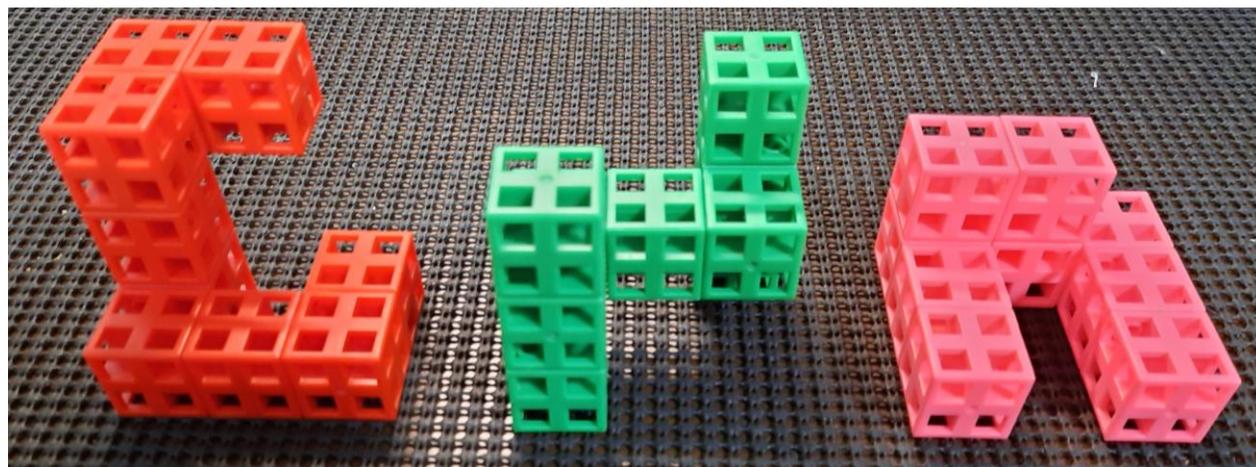
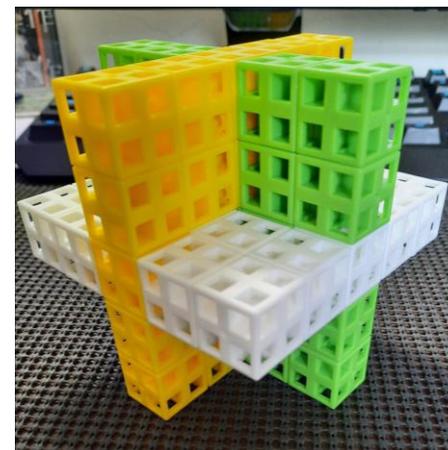
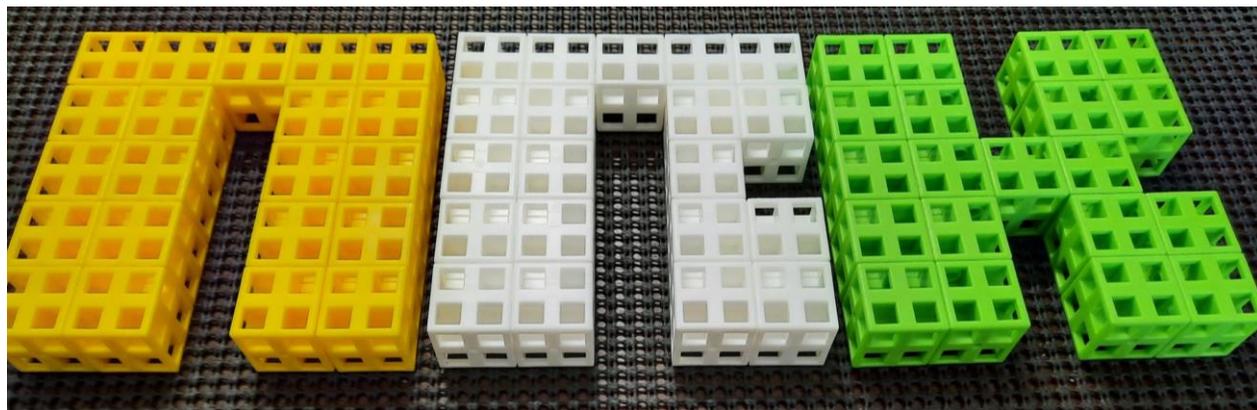
	組成形狀	組成方法數
平面	6×10 矩形	2399種
	5×12 矩形	1010種
	4×15 矩形	368種
	3×20 矩形	2種
立體	$3 \times 4 \times 5$ 立方體	394種
	$2 \times 5 \times 6$ 立方體	264種
	$2 \times 3 \times 10$ 立方體	12種



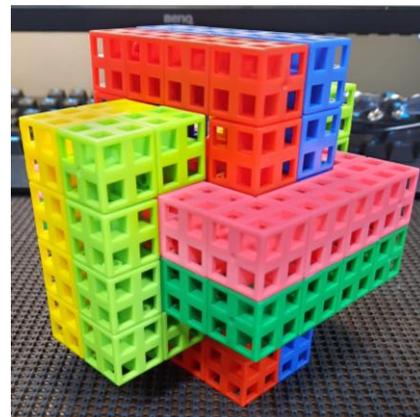
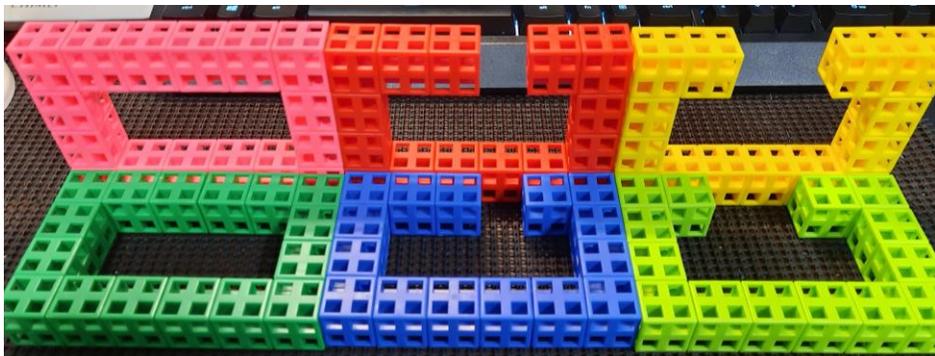
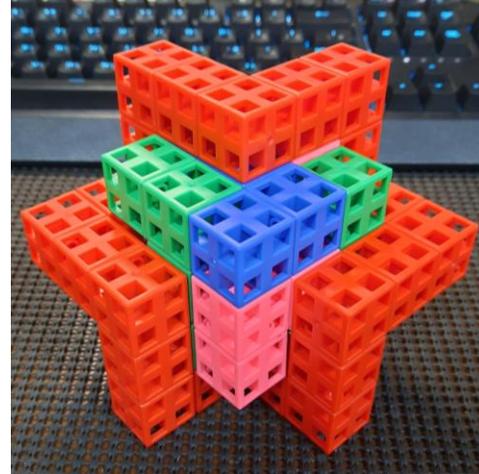
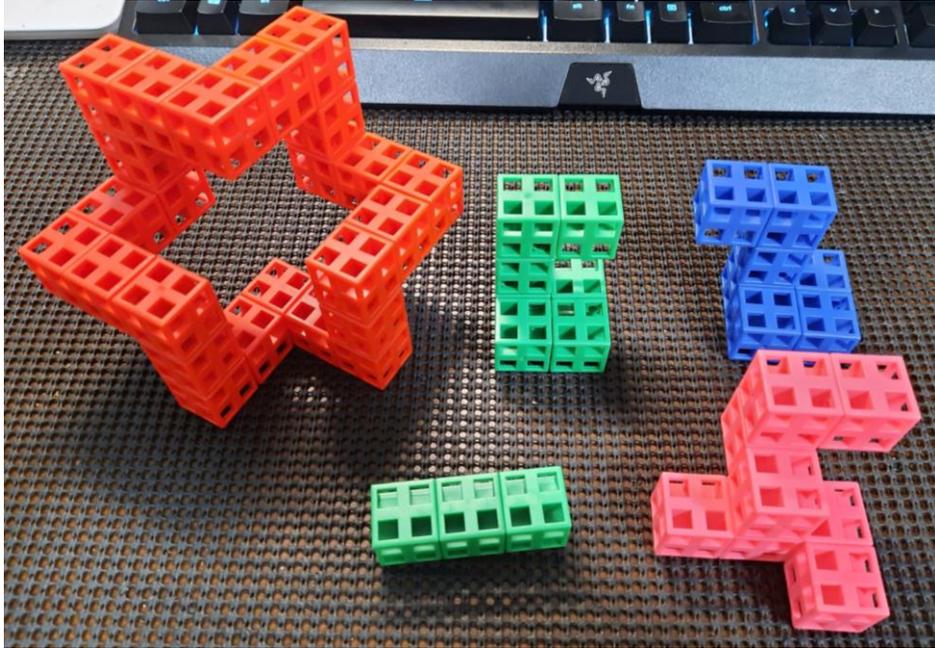
◆ 經典索瑪方塊 (SOMA Cube) :



◆ 組木展示：



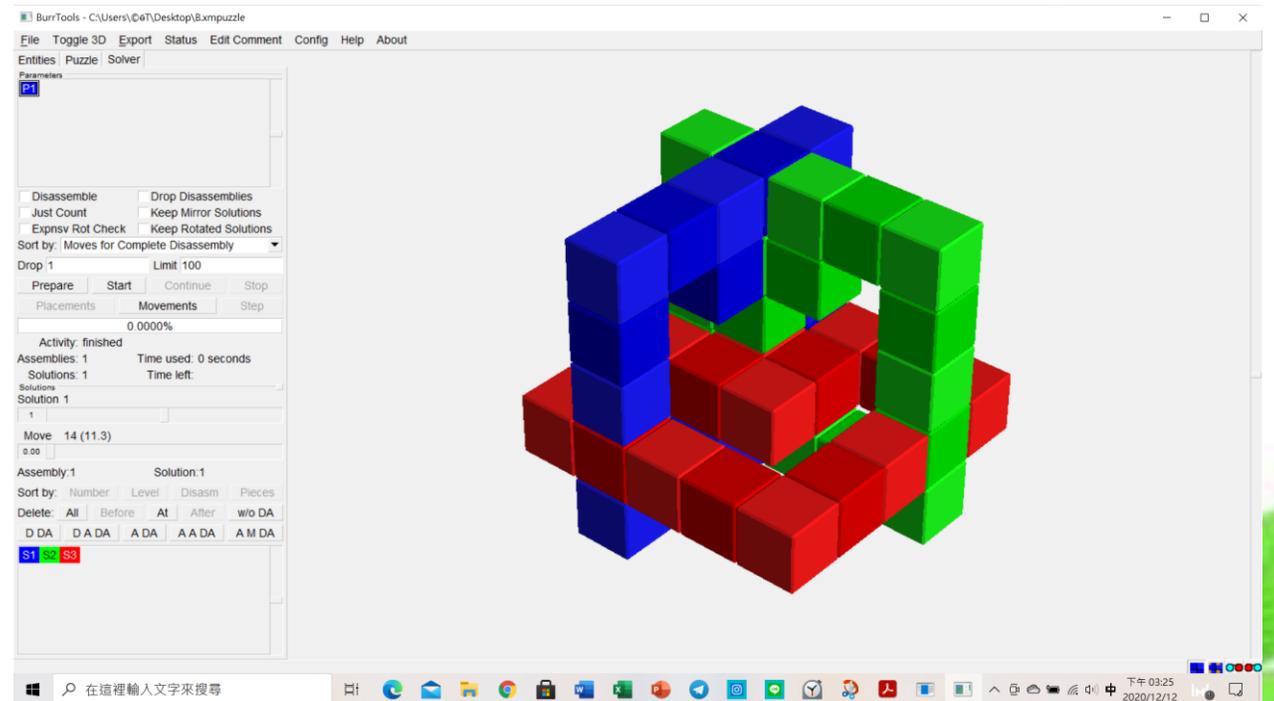
◆ 組木展示：



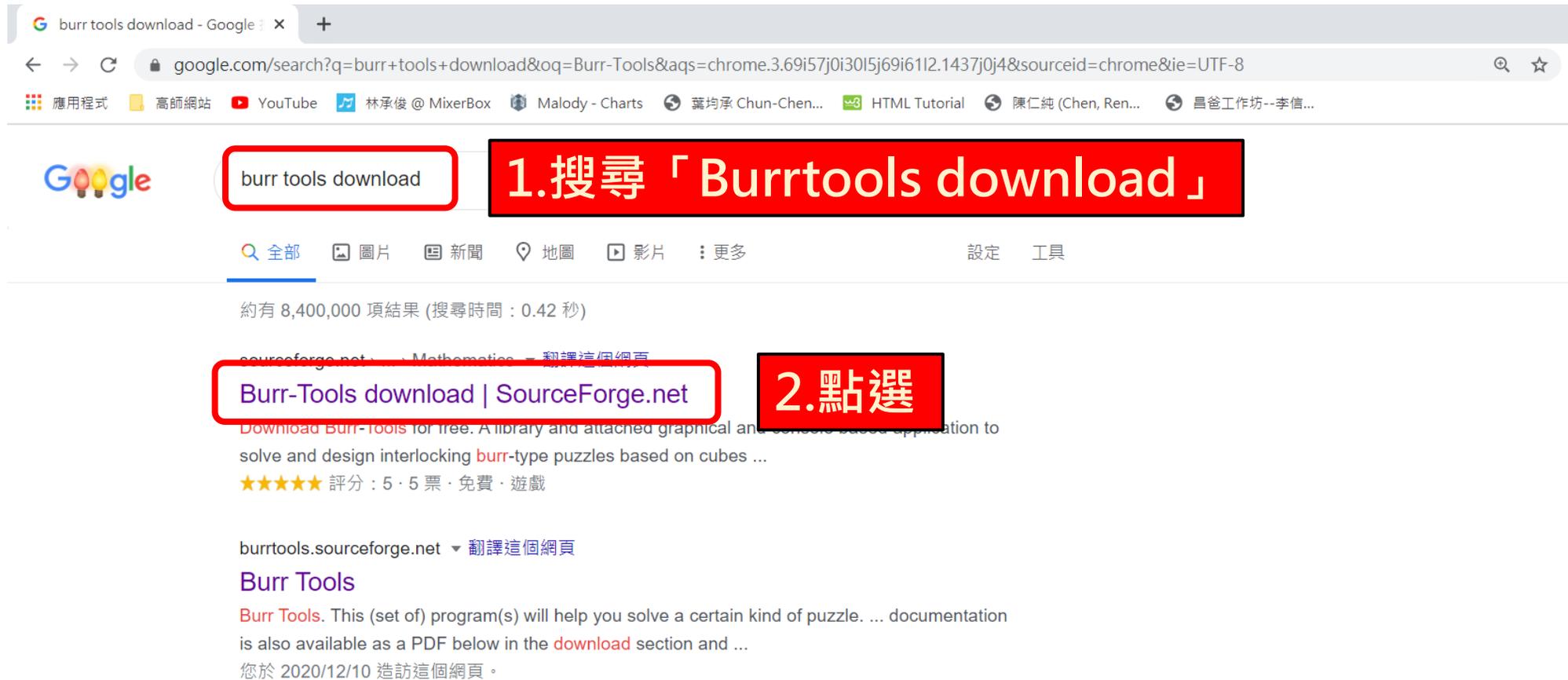
二、介紹Burrtools和操作方式

◆ 介紹內容包括：

- 基本建構組木與解決其問題
- Voxel介紹
- 組成單元之數量條件變化



◆ Burrtools軟體取得



The image shows a Google search interface. The search bar contains the text "burr tools download". A red box highlights the search bar, and a larger red box to its right contains the text "1. 搜尋「Burrtools download」". Below the search bar, the search results are displayed. The first result is from SourceForge.net, titled "Burr-Tools download | SourceForge.net". A red box highlights the title, and a larger red box to its right contains the text "2. 點選". The result description includes "Download Burr-Tools for free. A library and attached graphical and console based application to solve and design interlocking burr-type puzzles based on cubes ..." and a star rating of 5/5. Below the result, the URL "burrtools.sourceforge.net" and the title "Burr Tools" are visible. The description continues: "Burr Tools. This (set of) program(s) will help you solve a certain kind of puzzle. ... documentation is also available as a PDF below in the download section and ...". At the bottom of the result, it says "您於 2020/12/10 造訪這個網頁。".

Google burr tools download

1. 搜尋「Burrtools download」

全部 圖片 新聞 地圖 影片 更多 設定 工具

約有 8,400,000 項結果 (搜尋時間 : 0.42 秒)

sourceforge.net Mathematics 翻譯這個網頁

Burr-Tools download | SourceForge.net

2. 點選

Download Burr-Tools for free. A library and attached graphical and console based application to solve and design interlocking burr-type puzzles based on cubes ...

★★★★★ 評分 : 5 · 5 票 · 免費 · 遊戲

burrtools.sourceforge.net 翻譯這個網頁

Burr Tools

Burr Tools. This (set of) program(s) will help you solve a certain kind of puzzle. ... documentation is also available as a PDF below in the download section and ...

您於 2020/12/10 造訪這個網頁。



◆ Burrtools軟體取得

Burr-Tools download | SourceF x +

sourceforge.net/projects/burrtools/

應用程式 高師網站 YouTube 林承俊 @ MixerBox Malody - Charts 葉均承 Chun-Chen... HTML T

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 **Burr-Tools**
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★★★★★ 5 Reviews Downloads: 67 This Week

Download

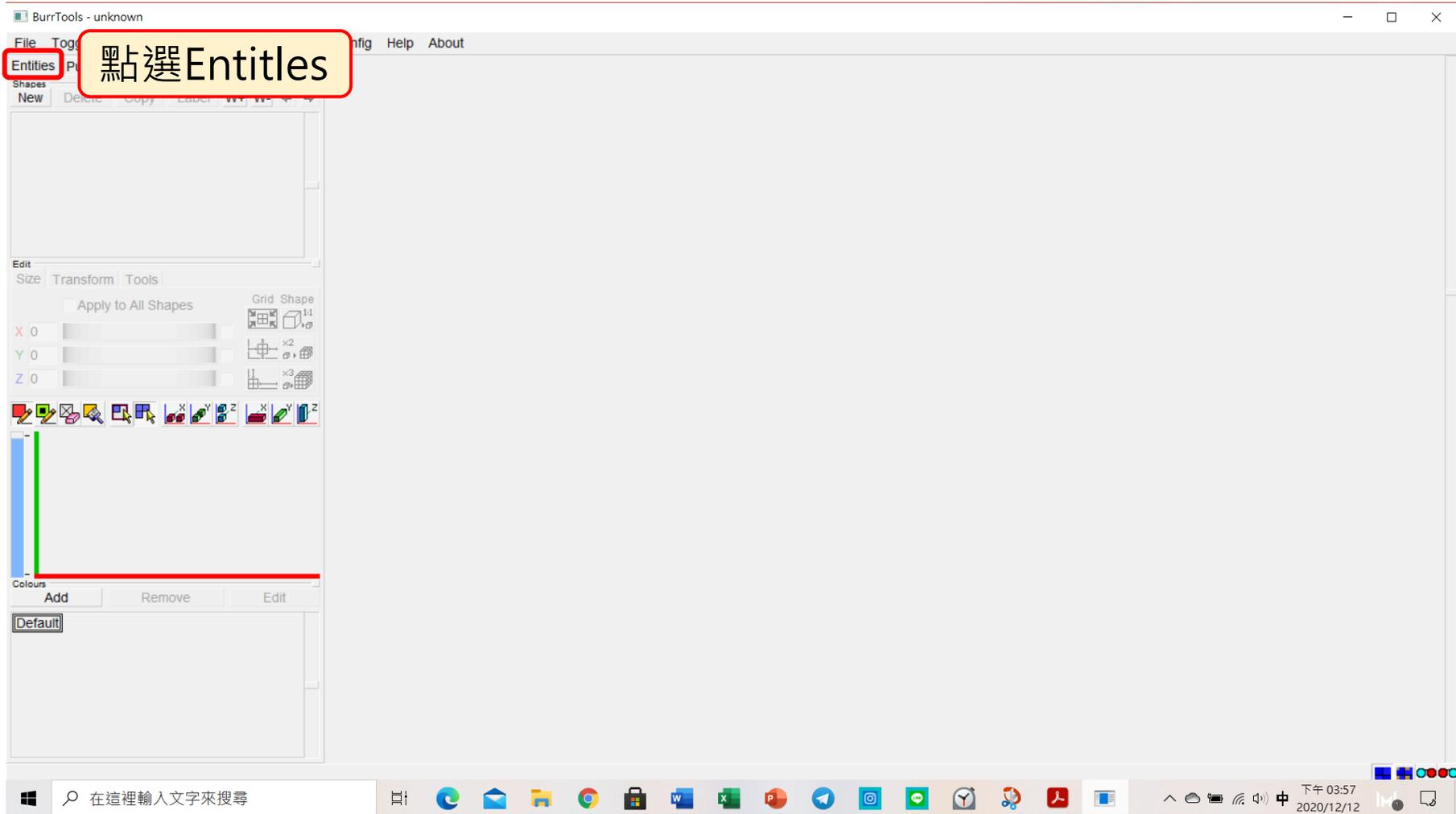
Windows | BSD | Linux

Summary | Files | Reviews | Support | Wiki

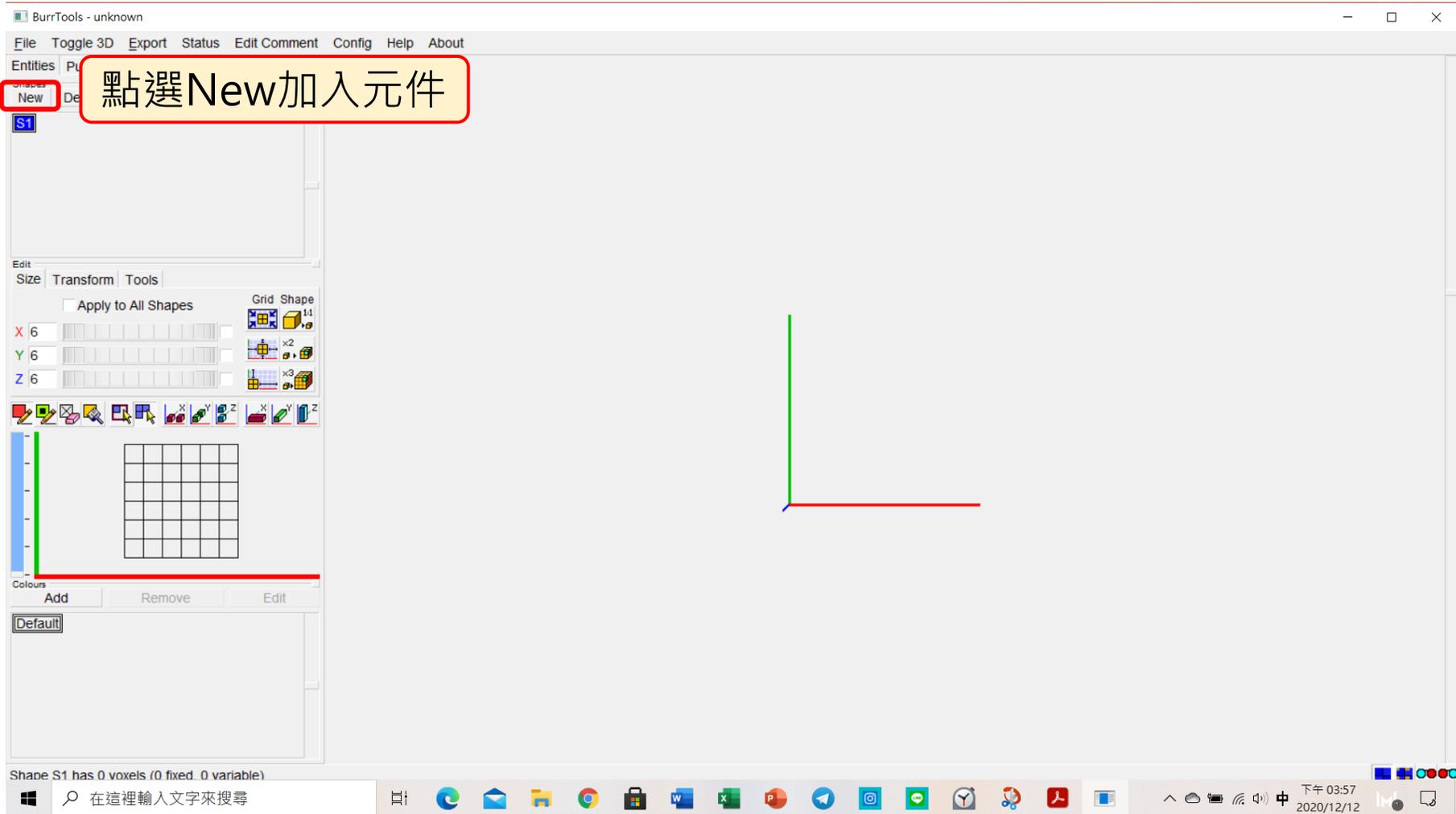
3. 下載後並解壓縮即可



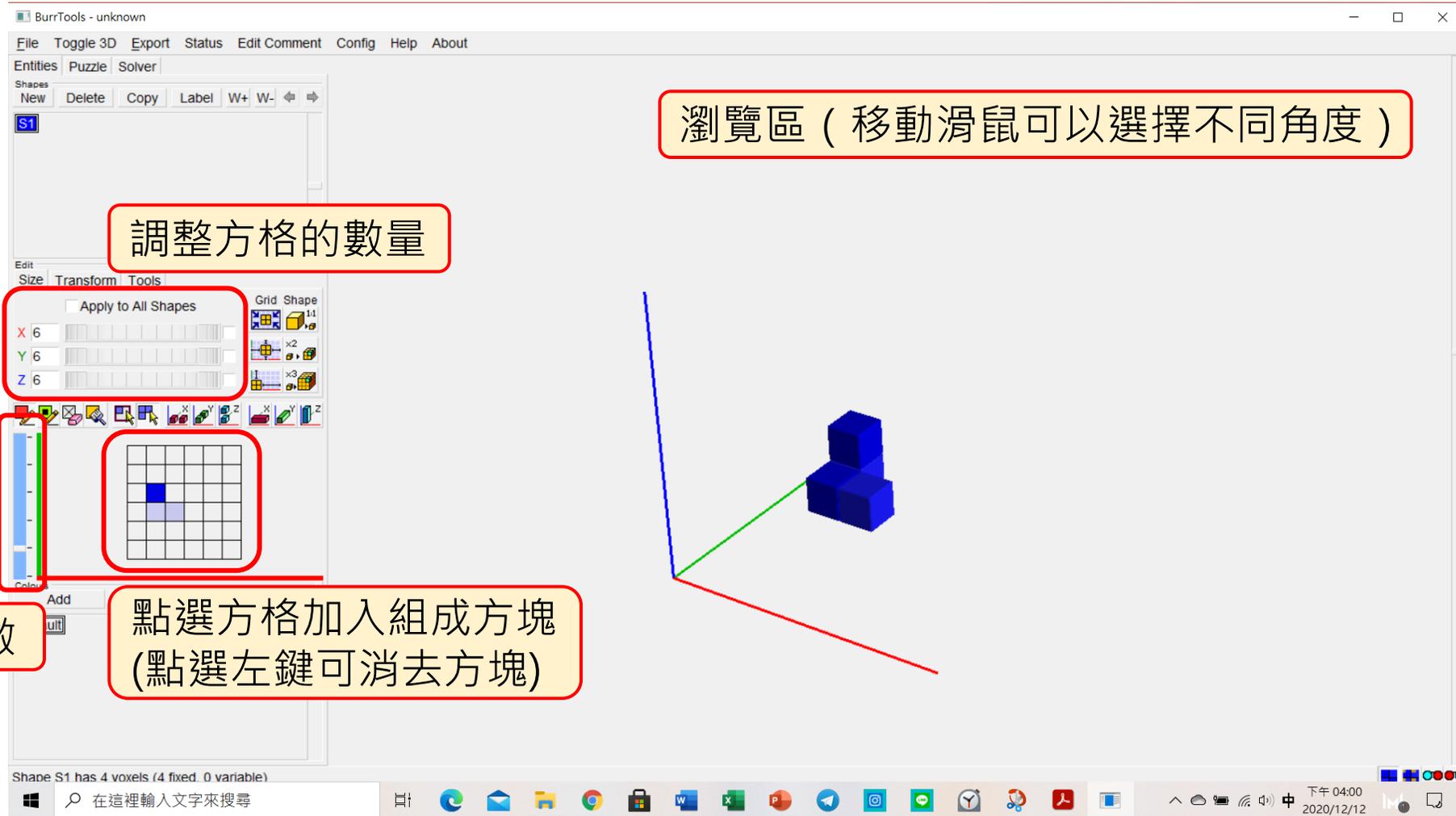
◆ 基本建構組木與解決其問題



◆ 基本建構組木與解決其問題



◆ 基本建構組木與解決其問題



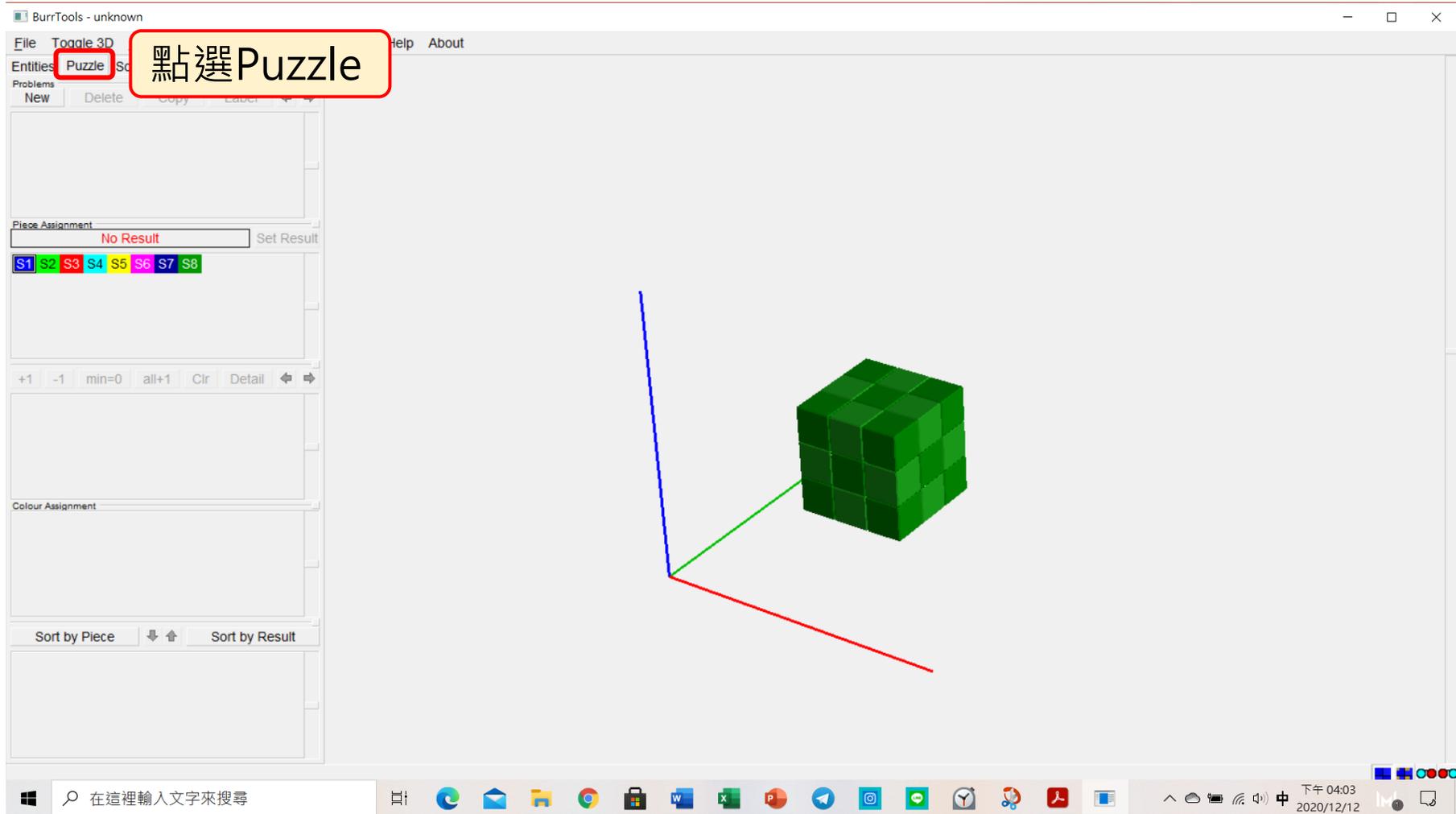
◆ 基本建構組木與解決其問題

The screenshot shows the BurrTools software interface. The main window displays a 3D cube composed of green voxels. A red box highlights the 'Entities' panel, which contains a list of shapes labeled S1 through S8, each with a different color. A yellow callout box with a red border contains the text: 陸續加入所有的組成方塊與目標組成的樣式. The interface also includes a menu bar (File, Toggle 3D, Export, Status, Edit Comment, Config, Help, About), a toolbar (New, Delete, Copy, Label, V+), and a 2D grid view showing the current shape's footprint. The status bar at the bottom indicates 'Shape S8 has 27 voxels (27 fixed, 0 variable)'. The Windows taskbar is visible at the bottom, showing the search bar and various application icons.

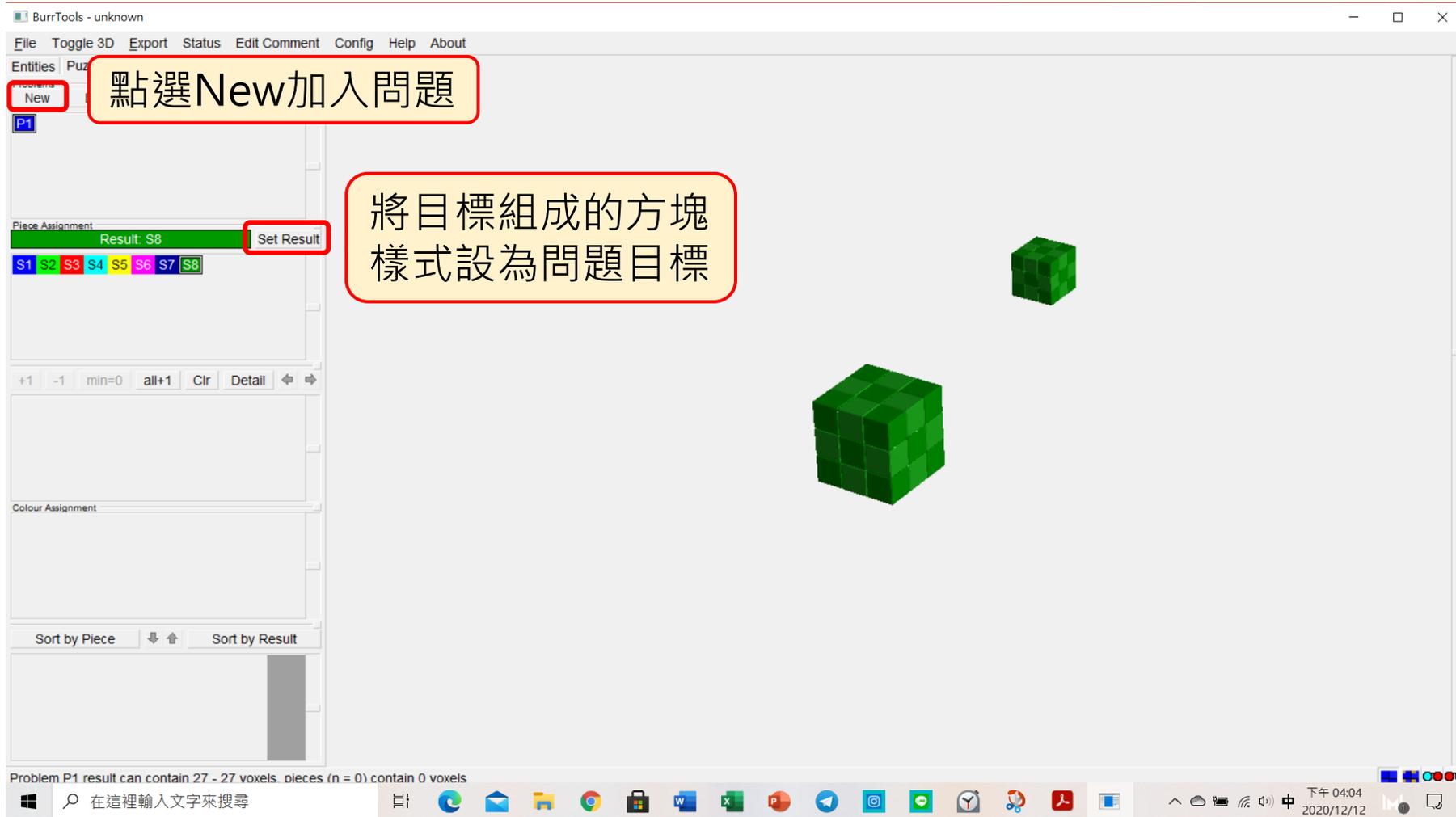
陸續加入所有的組成方塊與目標組成的樣式

Shape S8 has 27 voxels (27 fixed, 0 variable)

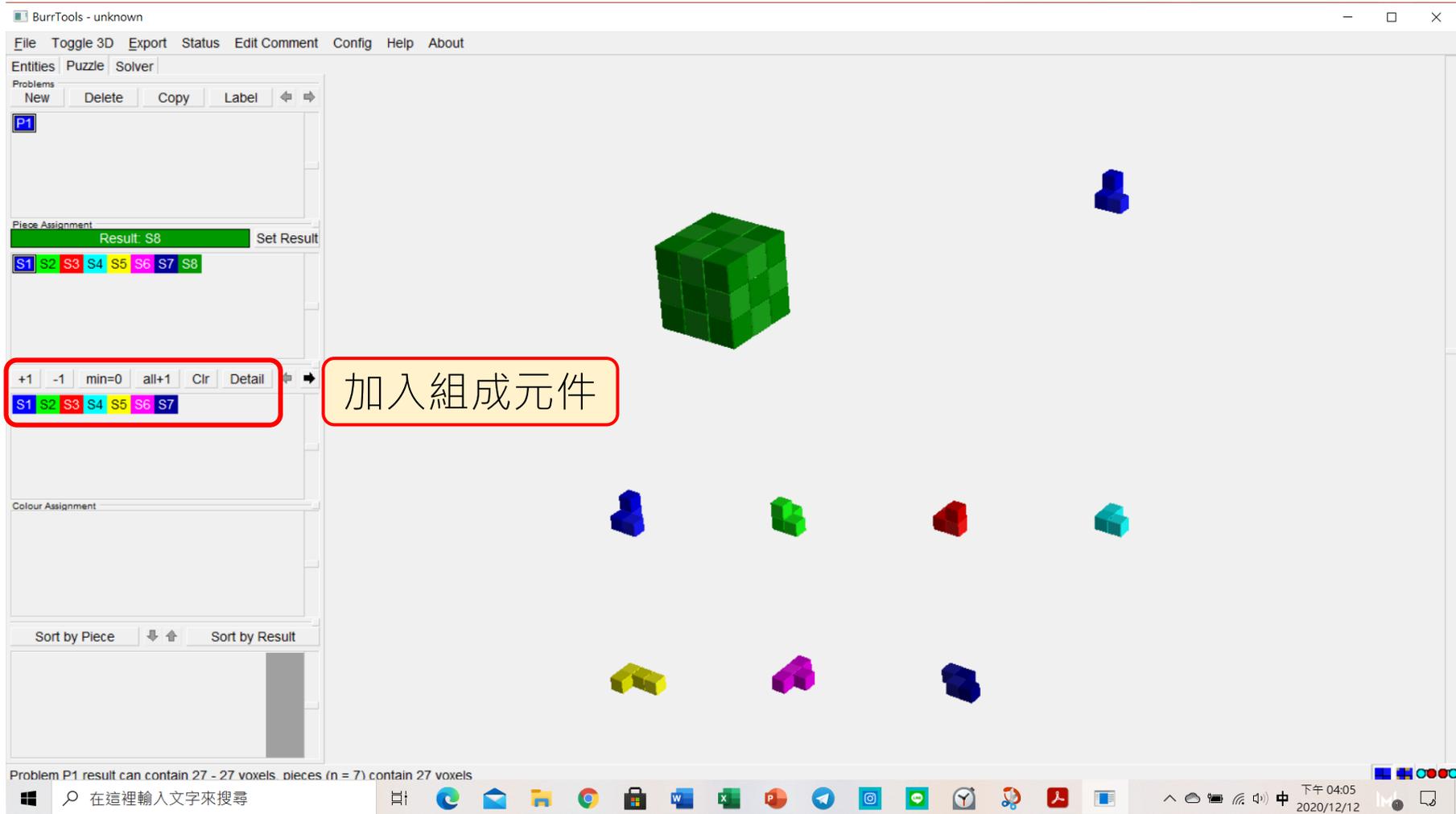
◆ 基本建構組木與解決其問題



◆ 基本建構組木與解決其問題



◆ 基本建構組木與解決其問題



◆ 基本建構組木與解決其問題

The image shows a screenshot of the BurrTools software interface. The window title is "BurrTools - unknown". The menu bar includes "File", "Toggle 3D", "Export", "Entities", "Puzzle", and "Solver". The "Solver" menu item is highlighted with a red box and labeled "點選Solver".

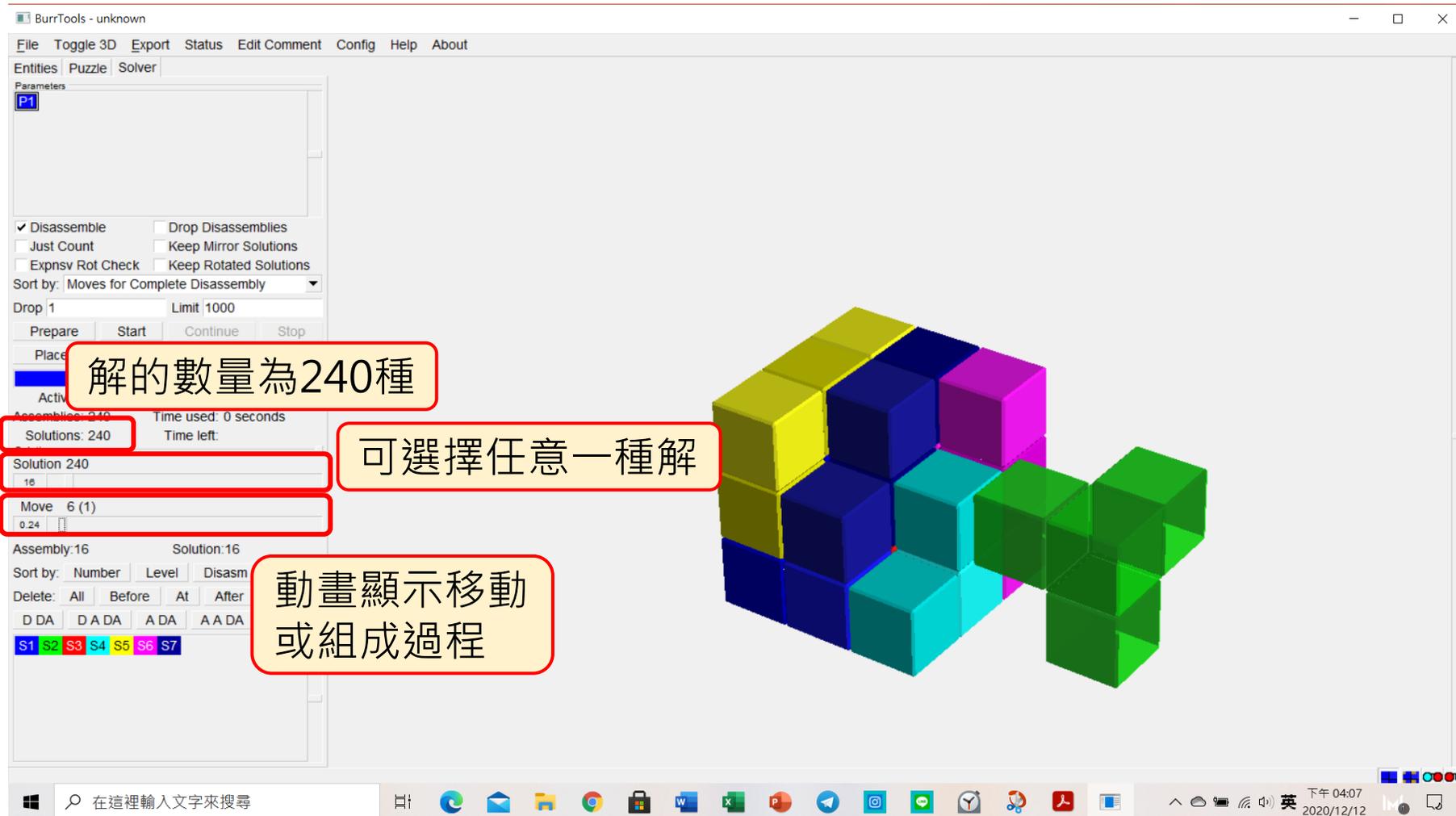
In the "Parameters" section, the "Disassemble" checkbox is checked and highlighted with a red box, labeled "勾選Disassemble". Below it, the "Start" button is highlighted with a red box and labeled "按下Start即可".

The main area displays a 3D model of a solved cube, which is highlighted with a red rounded rectangle and labeled "完成圖".

The interface also shows a progress bar at 100.0000%, activity status "finished", and various statistics like "Assemblies: 240", "Solutions: 240", and "Move 6 (1)". At the bottom, there is a taskbar with various application icons and a system tray showing the date and time: "下午 04:05 2020/12/12".

A yellow tooltip at the bottom of the interface reads: "Change appearance of the pieces between normal, grid and invisible".

◆ 基本建構組木與解決其問題



The screenshot displays the BurrTools application window. The main area shows a 3D assembly of colored blocks (yellow, blue, purple, cyan, green) arranged in a complex structure. The interface includes a menu bar (File, Toggle 3D, Export, Status, Edit Comment, Config, Help, About), a toolbar (Entities, Puzzle, Solver), and a Parameters panel. The Parameters panel has a 'P1' parameter and several checkboxes: 'Disassemble' (checked), 'Drop Disassemblies', 'Just Count', 'Keep Mirror Solutions', 'Expnsv Rot Check', and 'Keep Rotated Solutions'. A 'Sort by' dropdown is set to 'Moves for Complete Disassembly'. Below this are 'Drop 1' and 'Limit 1000' fields, and buttons for 'Prepare', 'Start', 'Continue', and 'Stop'. A 'Place' button is also visible. The 'Solutions' section shows 'Solutions: 240' and 'Time used: 0 seconds'. A 'Solution 240' is selected, showing 'Move 6 (1)' and '0.24'. The 'Assembly: 16' section shows 'Solution: 16' and a 'Sort by' dropdown set to 'Number'. Below this are 'Delete' options (All, Before, At, After) and a list of moves: 'D DA', 'D A DA', 'A DA', 'A A DA', and 'S1 S2 S3 S4 S5 S6 S7'. The Windows taskbar at the bottom shows the search bar, taskbar icons, and system tray with the date and time '2020/12/12 下午 04:07'.

解的數量為240種

可選擇任意一種解

動畫顯示移動或組成過程

◆ Voxel介紹

- Burrrtools的每一個空間單位叫做一個voxel，都有**fixed**（**固定**）、**empty**（**空**）及**variable**（**可變**）三種狀態。形體外觀的voxel都是可見且確定的，因此為fixed狀態。然而內部空間的voxel則無法確定其狀態為fixed或empty，因此我們必須將這些voxel的狀態，繪成variable
- 簡言之，將voxel的狀態繪成variable的時機大多為**未知或已知空洞、無法看見的區域（圖形不可視區）**等

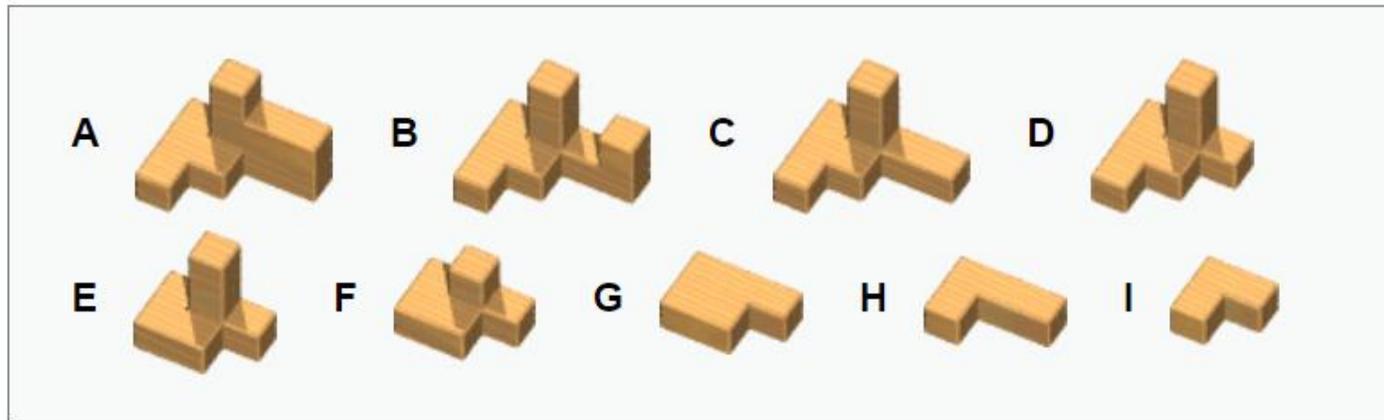


◆ Voxel介紹

Void!

10 

Design and Copyright : [László Molnár](#) (2018).

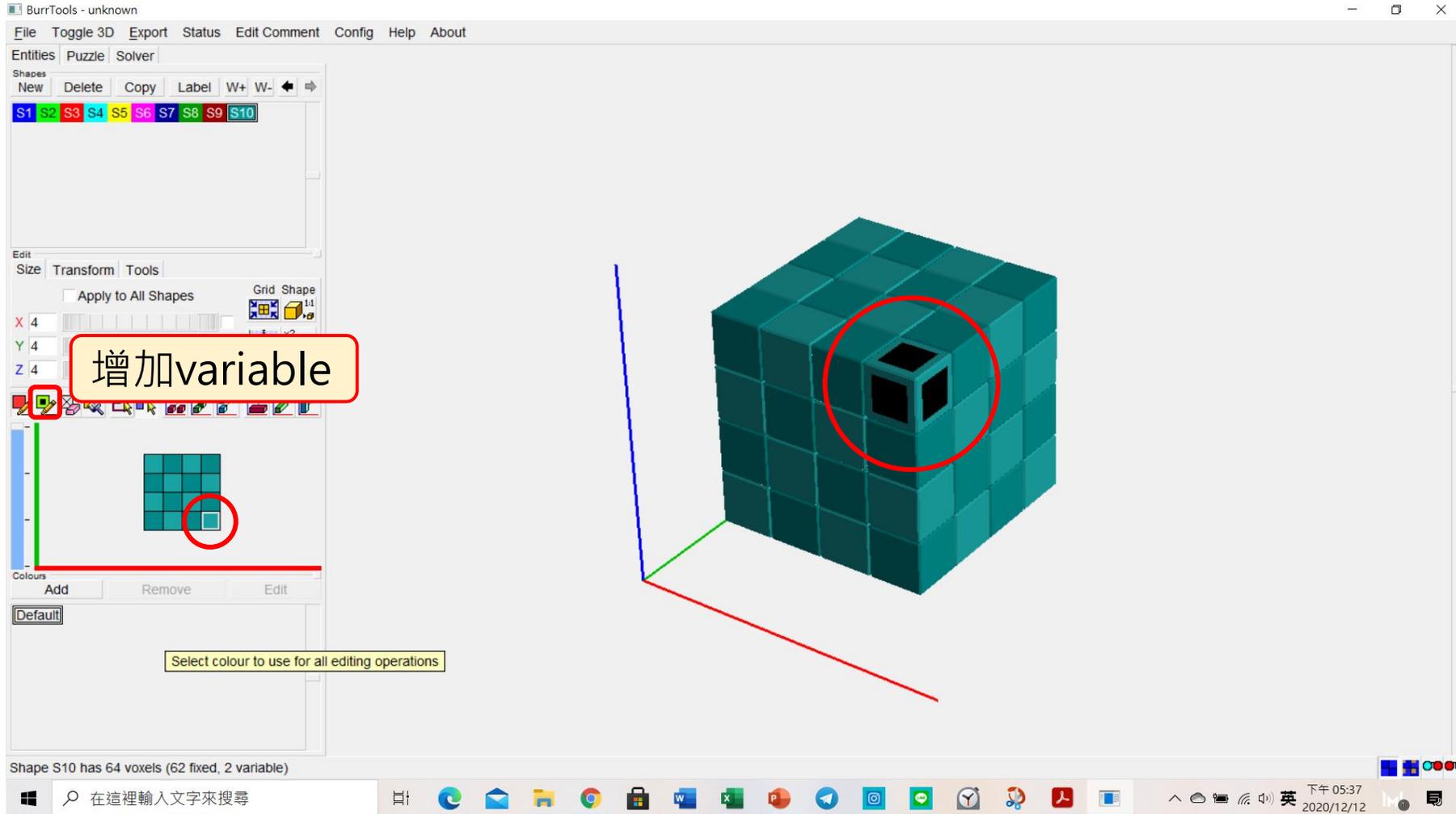


Pieces	9
Goal	4×4×4
Holes	1
Solutions	1
	10

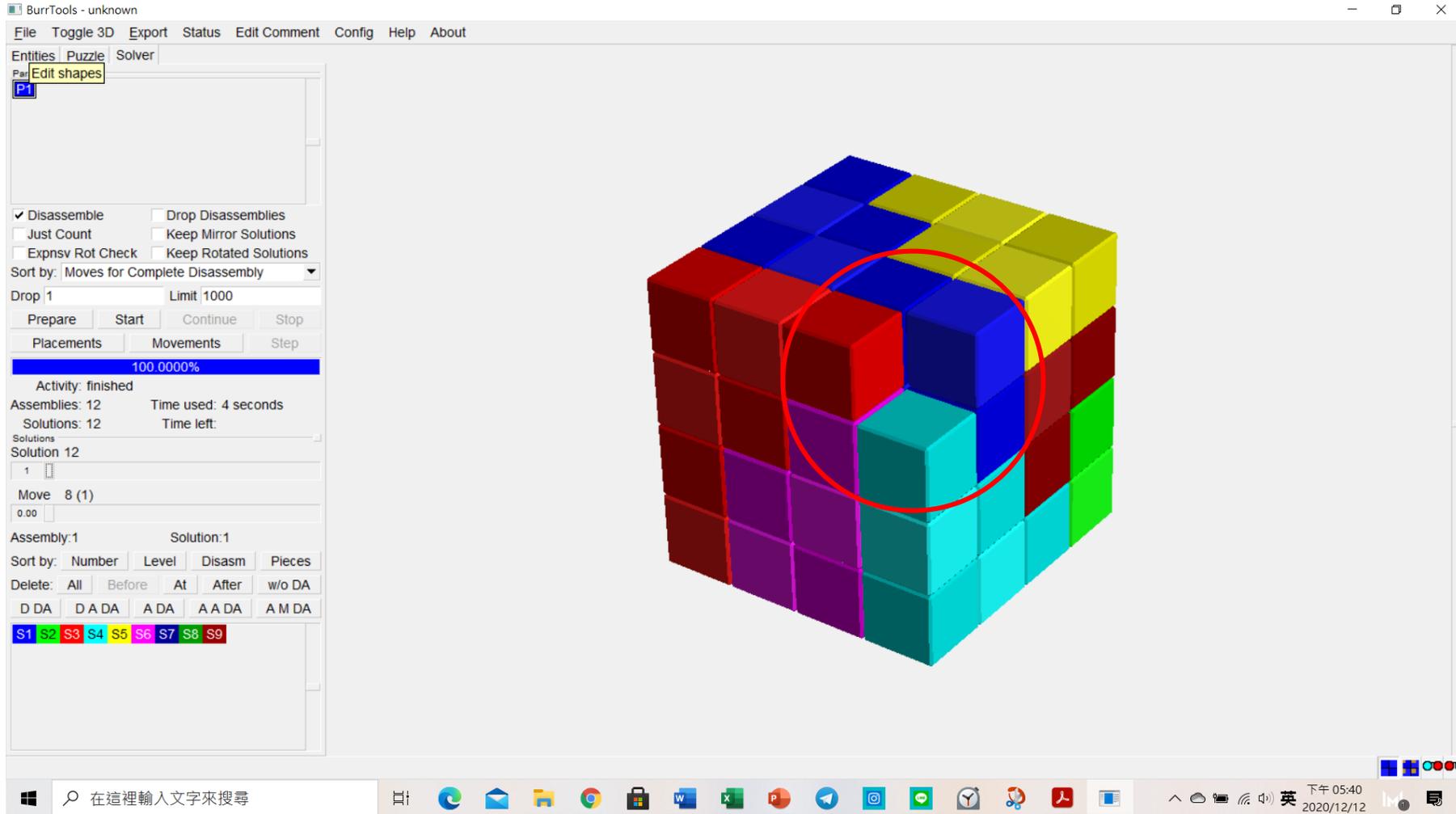
Inside Hole.
Outside Hole.



◆ Voxel介紹



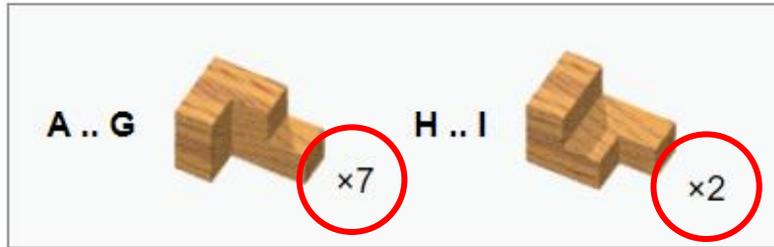
◆ Voxel介紹



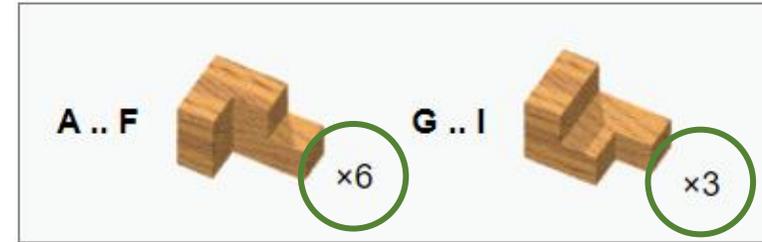
◆ 組成單元之數量條件變化

Booties

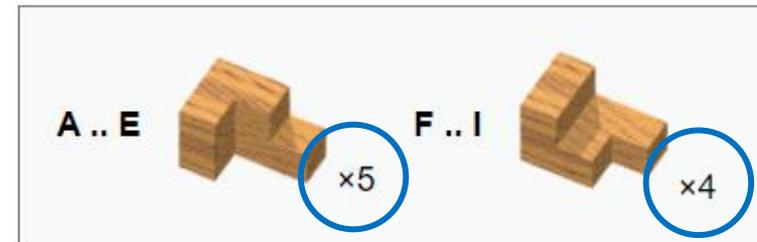
Design and Copyright : [Bram Cohen](#) (2011).  [Unhappy Woodworm 2](#)



Pieces	9	A-G, H-I are congruent.
Goal	4x4x4	
Holes	1	
Solutions	1	



Pieces	9	A-F, G-I are congruent.
Goal	4x4x4	
Holes	1	
Solutions	1	



Pieces	9	A-E, F-I are congruent.
Goal	4x4x4	
Holes	1	
Solutions	1	



◆ 組成單元之數量條件變化

The screenshot displays the BurrTools software interface. On the left, the 'Problem Details' window is open, showing a table with columns 'Shape', 'Min', and 'Max'. The table contains the following data:

Shape	Min	Max
S1	5	7
S2	2	4
S3	0	0

A red box highlights the 'Min' and 'Max' columns in the table. A yellow callout box with a red border contains the text '改變元件各數的上下限' (Change the upper and lower limits of the number of components). The main interface shows a puzzle problem 'P1' with a 'Piece Assignment' section displaying 'Result: S3' and 'Set Result' buttons. Below this, there are buttons for '+1', '-1', 'min=0', 'all+1', 'Clr', and 'Detail'. The 'Detail' button is highlighted with a red box. The 'Colour Assignment' section is empty. At the bottom, the status bar indicates 'Problem P1 result can contain 61 - 64 voxels, pieces (n = 11) contain 49-77 voxels'. The Windows taskbar is visible at the bottom, showing the search bar and various application icons.

三、Burrtools實際操作應用



四、著名例子介紹&延伸探究

◆ 榫卯工藝 (木工工藝)



▲ 平板明榫角結合



▲ 平板明榫角結合



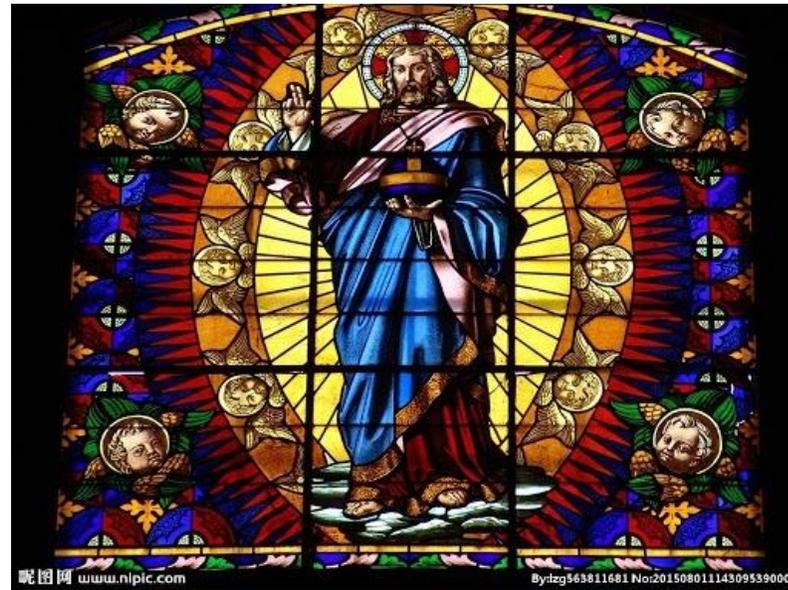
▲ 楔釘榫



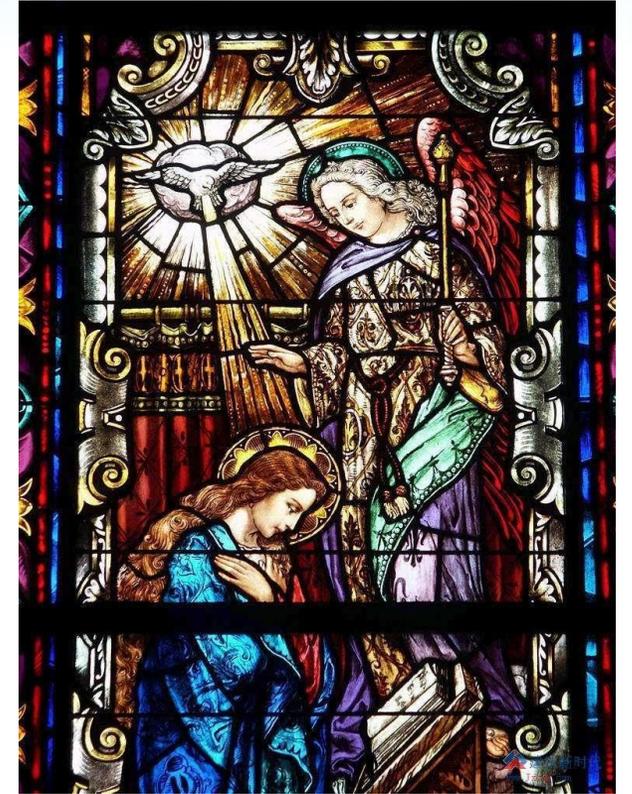
◆ 拼圖和彩繪玻璃



▲ 七巧板



▲ 彩繪玻璃



▲ 彩繪玻璃



◆ 藝術拼貼地板畫



© Can Stock Photo - csp15684148



◆ 益智遊戲



▲ 聖劍puzzle



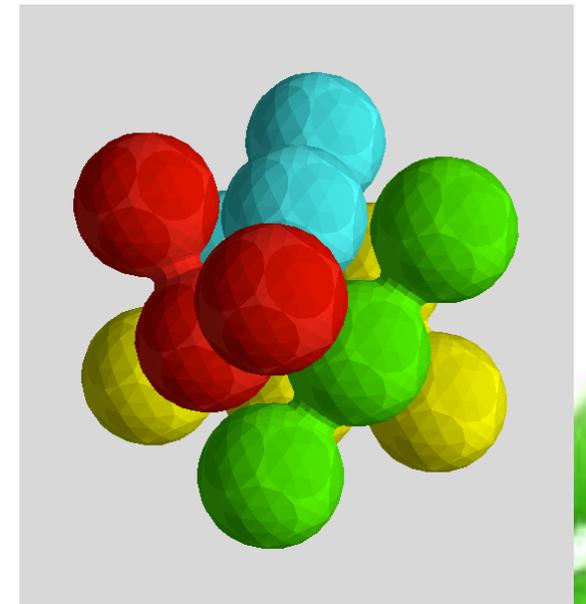
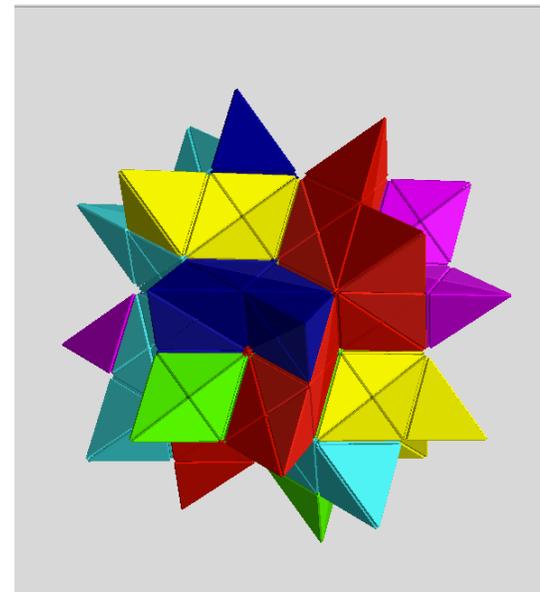
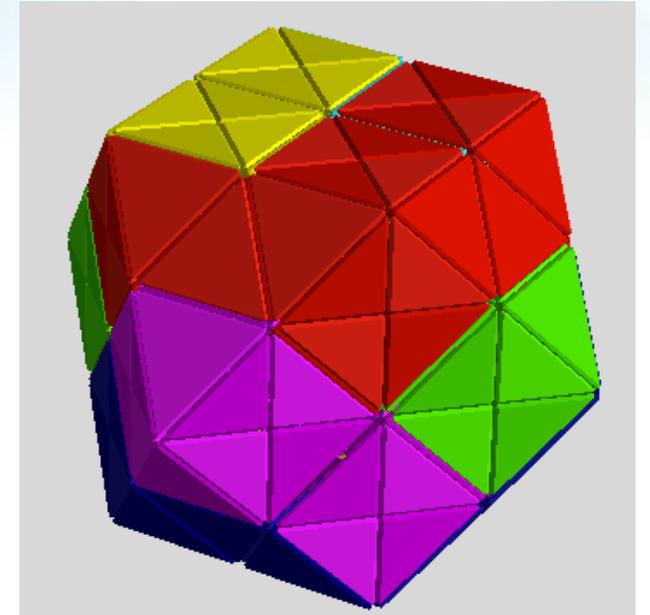
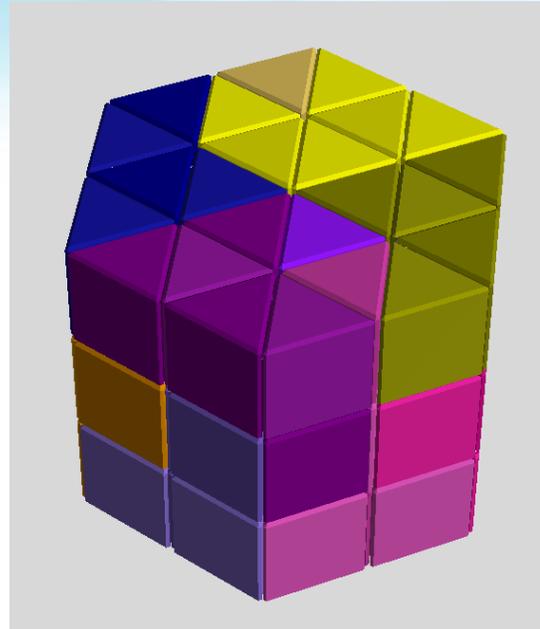
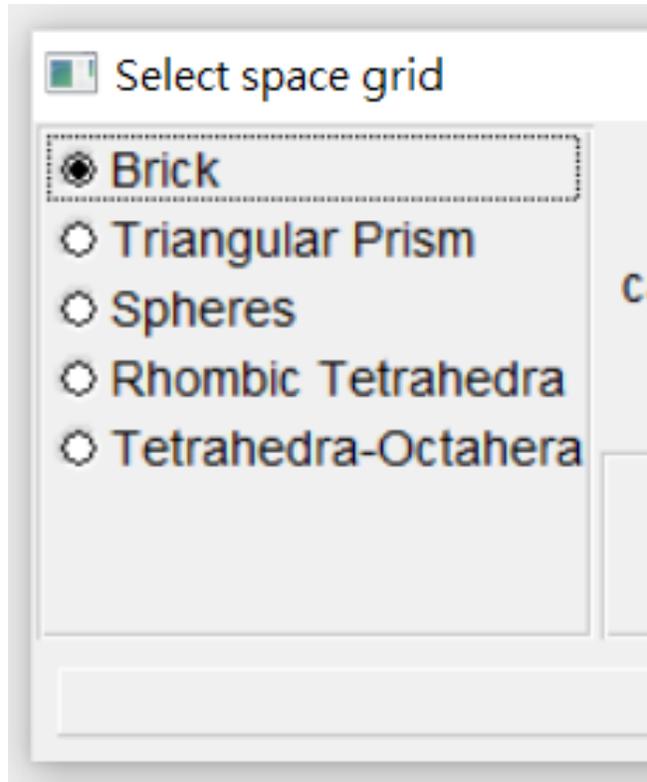
▲ 魯班鎖



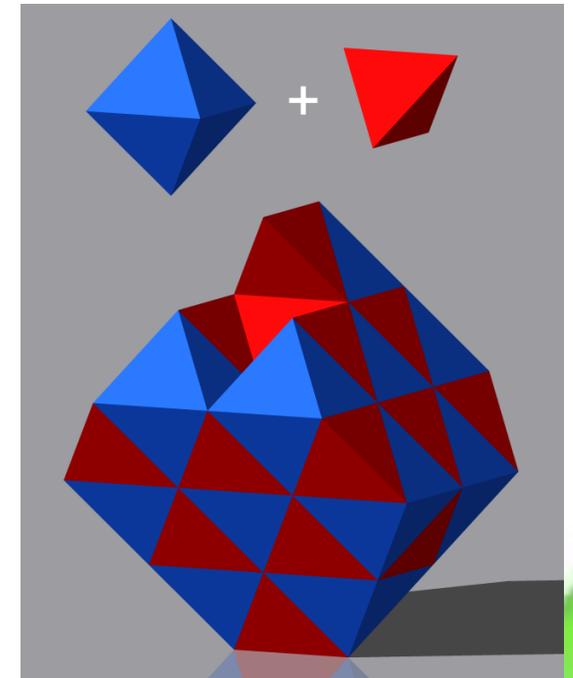
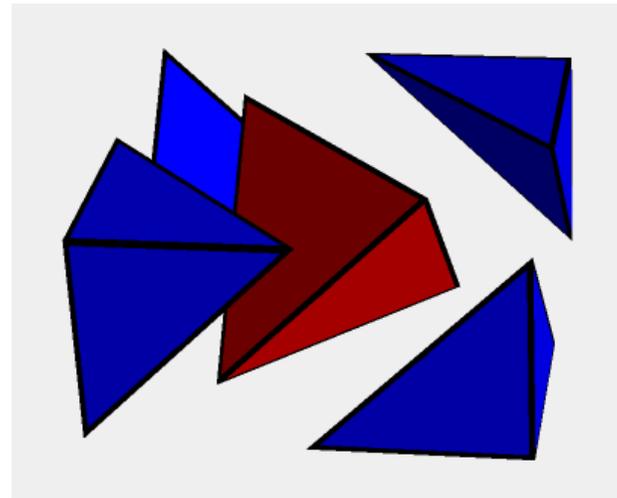
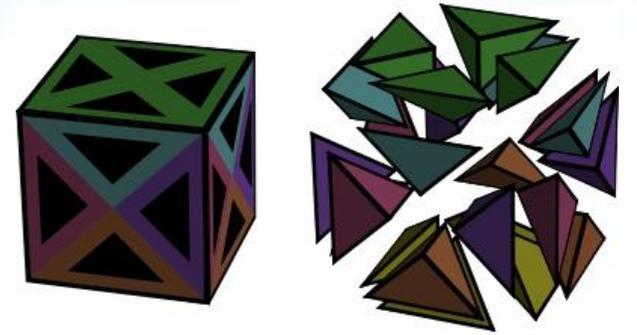
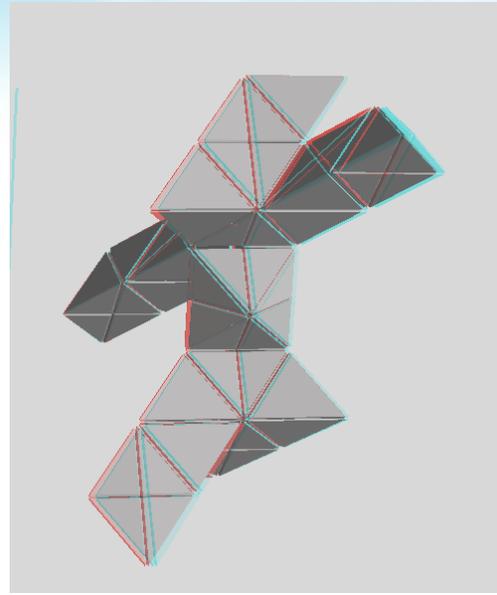
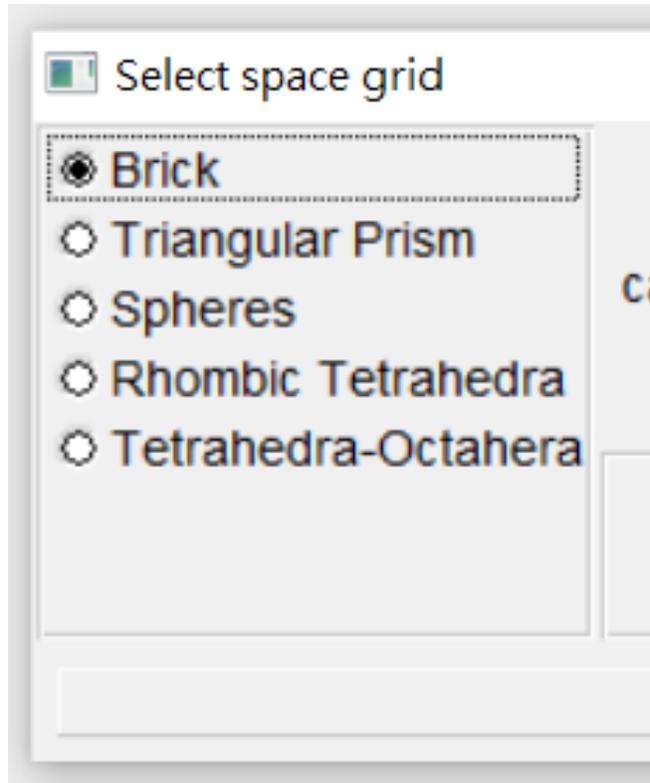
▲ 魯班盒



◆ 延伸與展望



◆ 延伸與展望



五、結語

我們利用多方塊積木的組合方式，像蓋房子一樣展現出不同的多面變化、空間分析...等，同時也是多數人童年的益智玩具。以上是我們這組一起共同合作完成的積木實際操作，並透過Burrtools軟體，判定多方塊組木之組合有解或無解，進而做出以上的實際操作；而生活中息息相關榫卯工藝（木工工藝）、拼圖和彩繪玻璃、藝術拼貼地板畫...等，其實也都內含著這些組木的概念。最後我們發現不只是正方體方塊有這些有趣的特性和組合，若將正方體推廣至球體、四面體...等，似乎也都有著類似的特性。這次的報告是大家經過多番討論之後，很努力一起共同完成的。



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