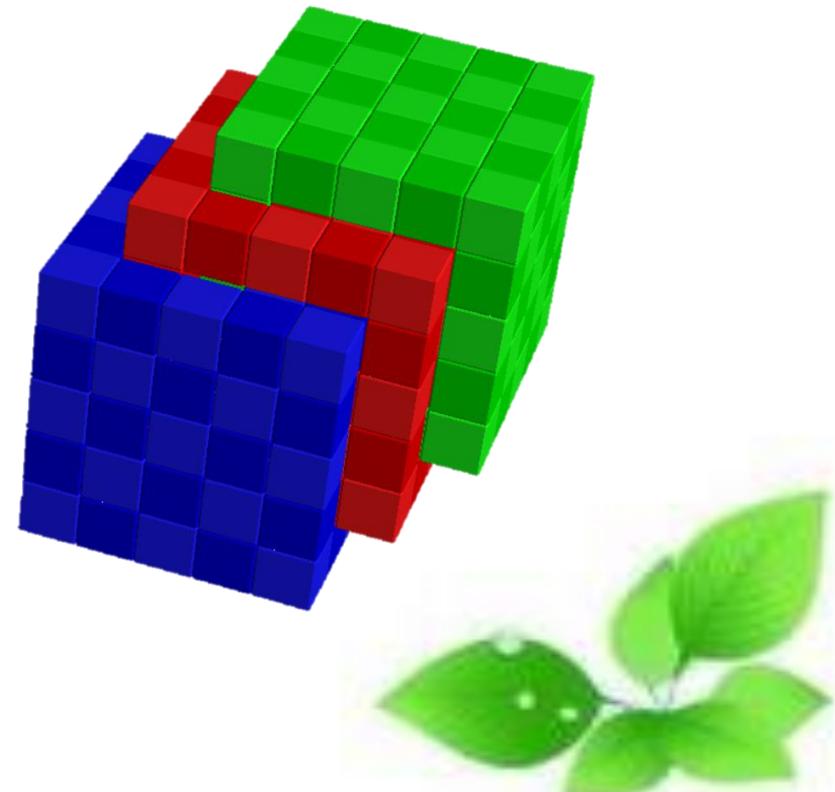


# 多方塊積木和組木之探索

組員：徐丙忠、林承俊、邱嵩槐、溫成鐘、黃虹菱



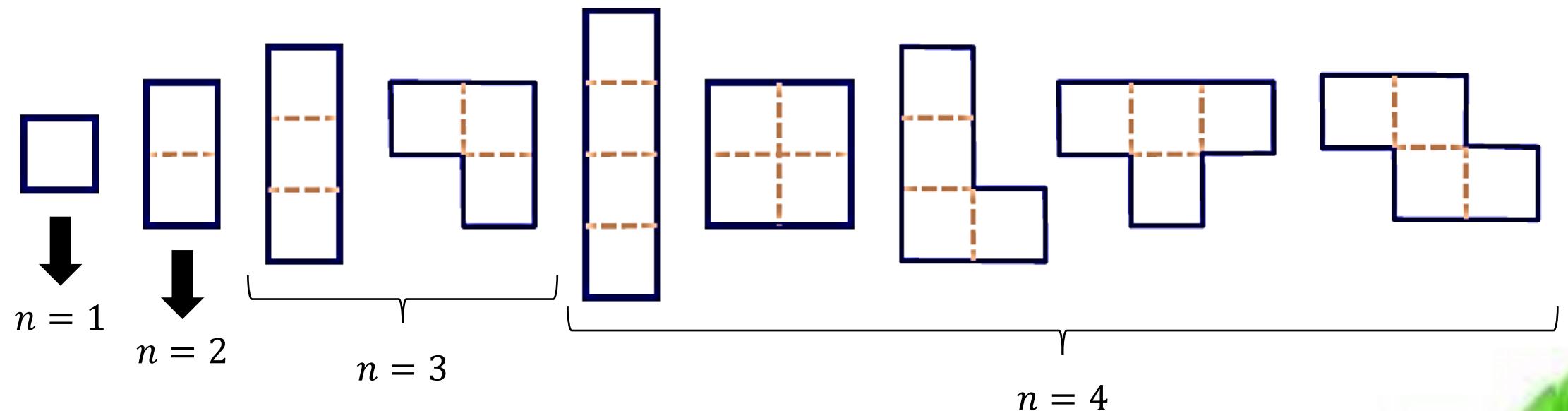
# 【大綱】

- 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



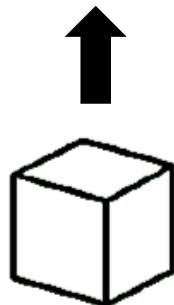
# 一、多方塊積木和組木之介紹

- ◆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：

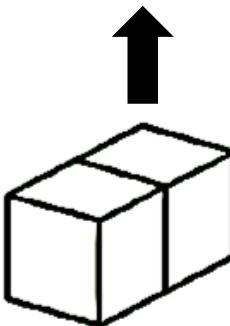


◆ 將多方塊在平面上的概念藉由立體化擴充到三維空間，形成多個正方體的相連。同理，考慮 $n \leq 4$ 時，可以構成以下12種圖形：

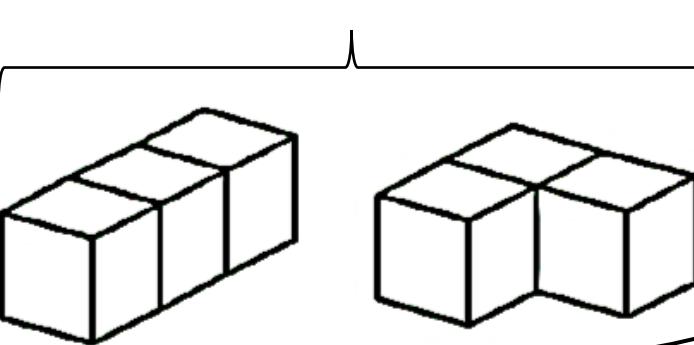
$$n = 1$$



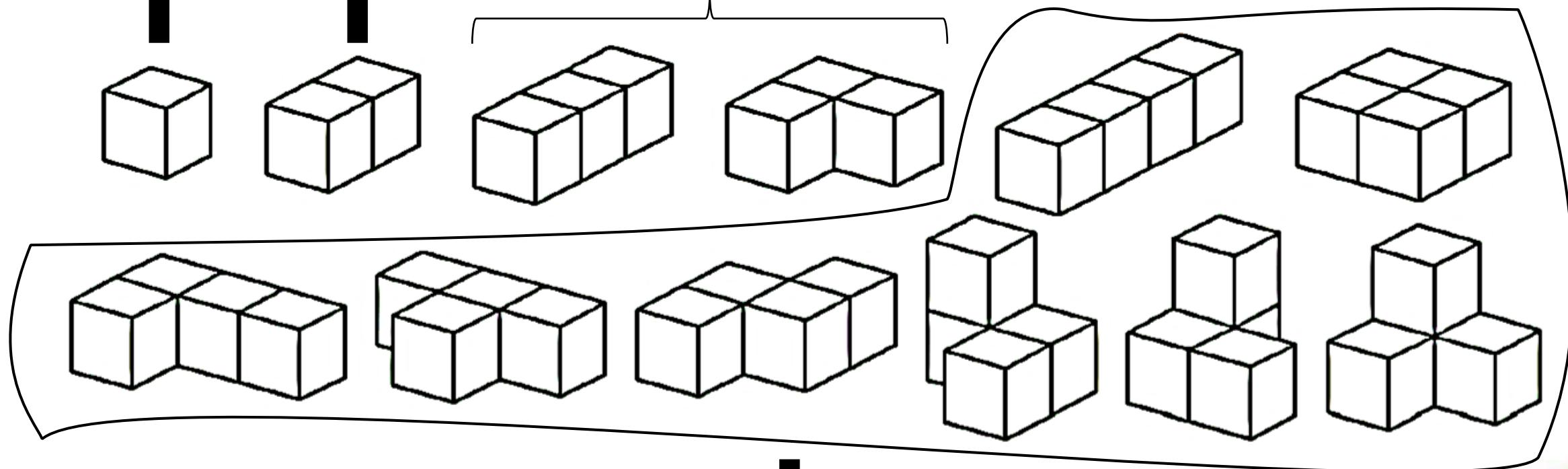
$$n = 2$$



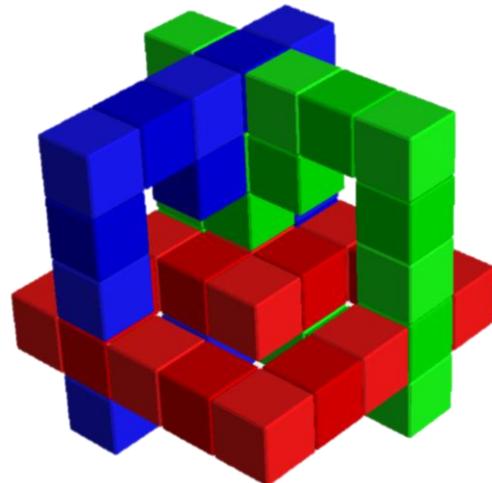
$$n = 3$$



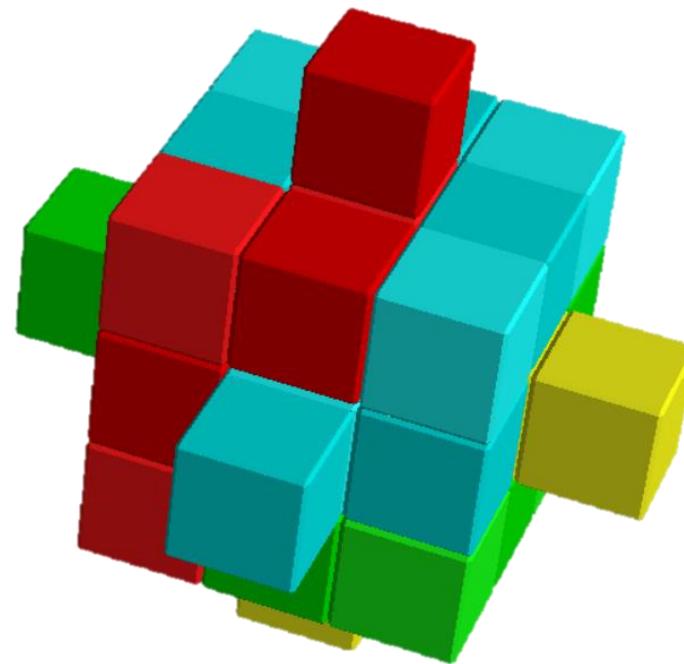
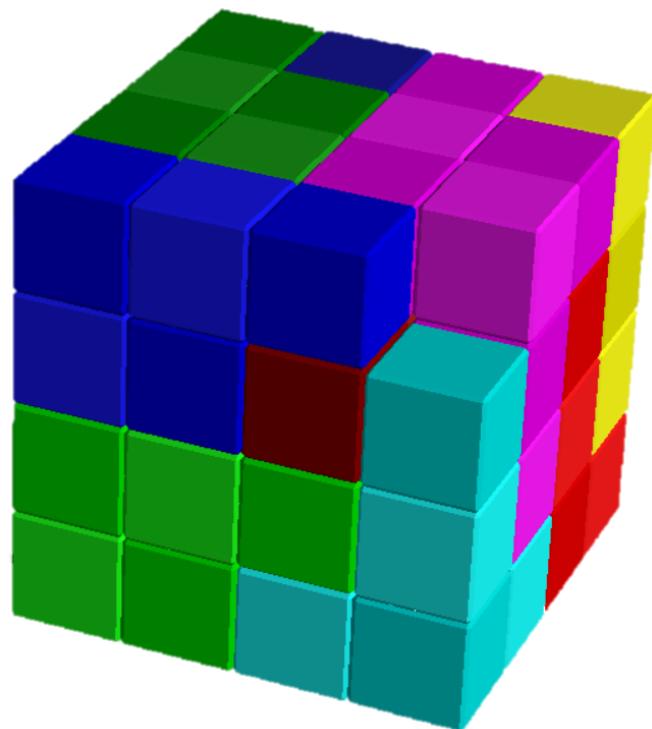
$$n = 4$$



◆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「三桿組木 ( 3 pieces burr ) 」、「六桿組木 ( 6 pieces burr ) 」、「魯班鎖」、「孔明鎖」...等，且因為早期組木的設計趨勢朝向「更多桿件」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

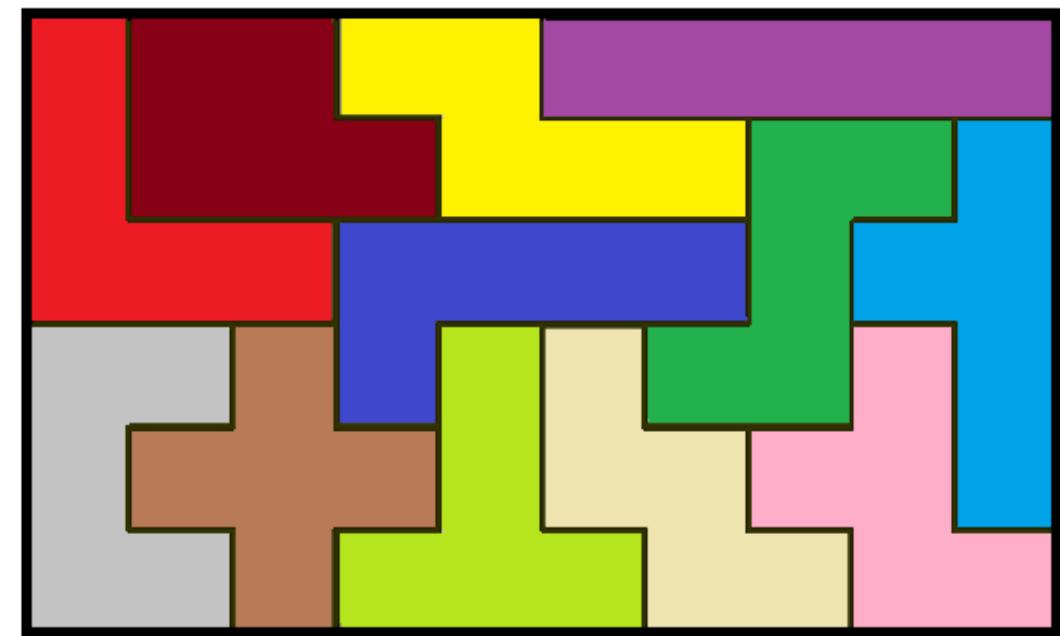


◆ 積木 ( Put-together puzzle ) 類的益智玩具，就是要將所有的玩具組件給堆疊、排列成為「特定的形體」，或是放入特定的容器之中。而這也是益智玩具中歷史最悠久，數量最多的一個類別，同時也是我們生活中最常接觸到的玩具類型。

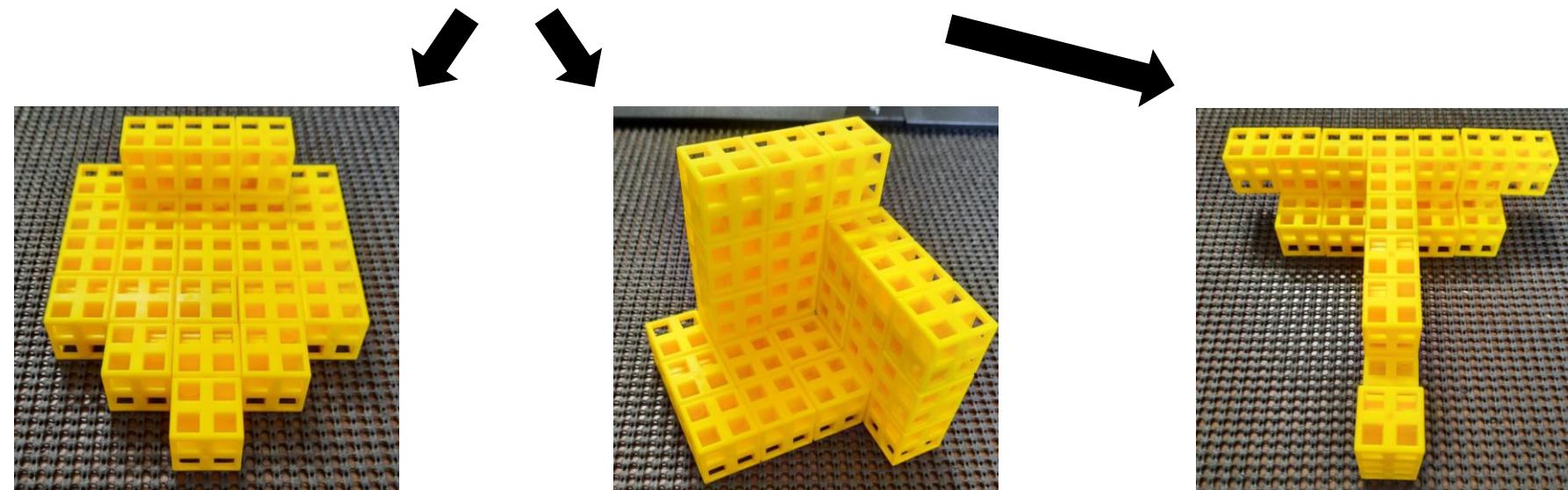
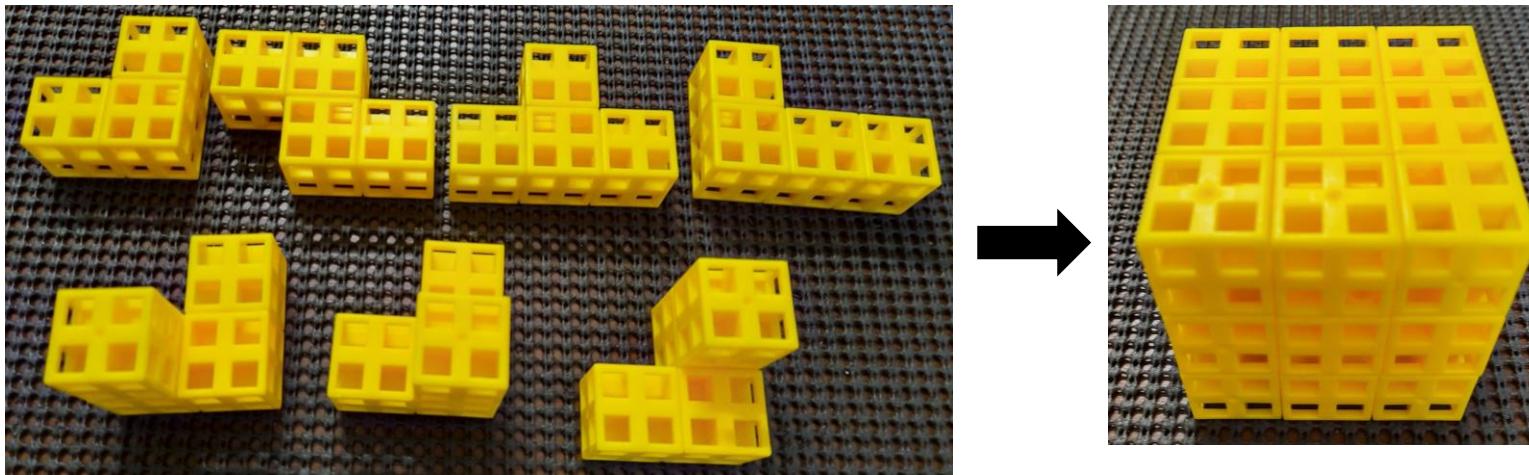


◆最早流行的多方塊積木為平面5 – 方塊組（Pentomino set）亦稱為「五方連」，有如下圖所示12種形狀，共有 $12 \times 5 = 60$  平方單位，故可以拼成如下幾種形狀：

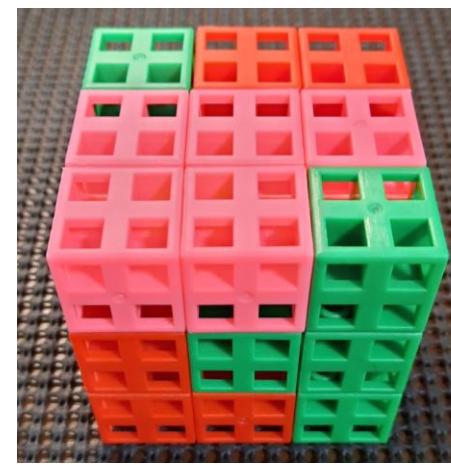
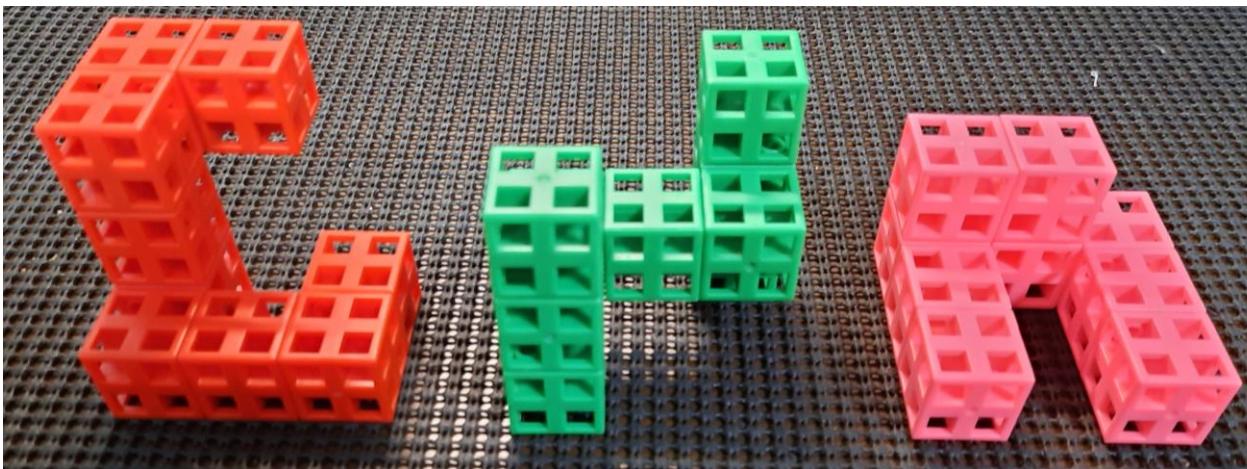
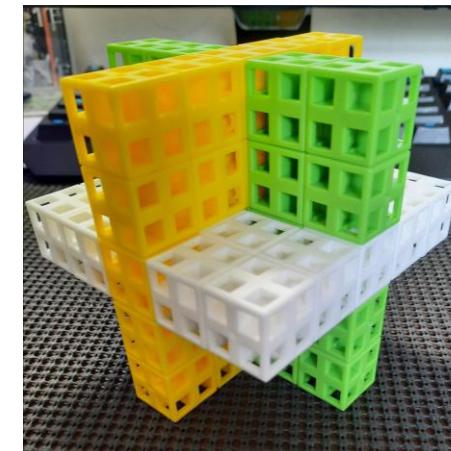
	組成形狀	組成方法數
平面	$6 \times 10$ 矩形	2399種
	$5 \times 12$ 矩形	1010種
	$4 \times 15$ 矩形	368種
	$3 \times 20$ 矩形	2種
立體	$3 \times 4 \times 5$ 立方體	394種
	$2 \times 5 \times 6$ 立方體	264種
	$2 \times 3 \times 10$ 立方體	12種



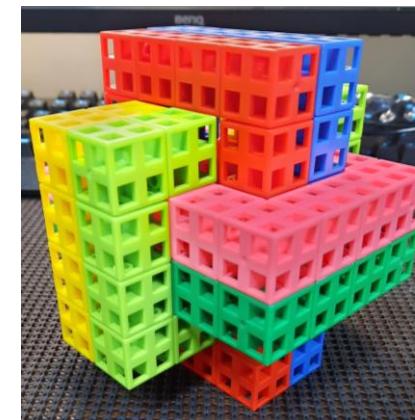
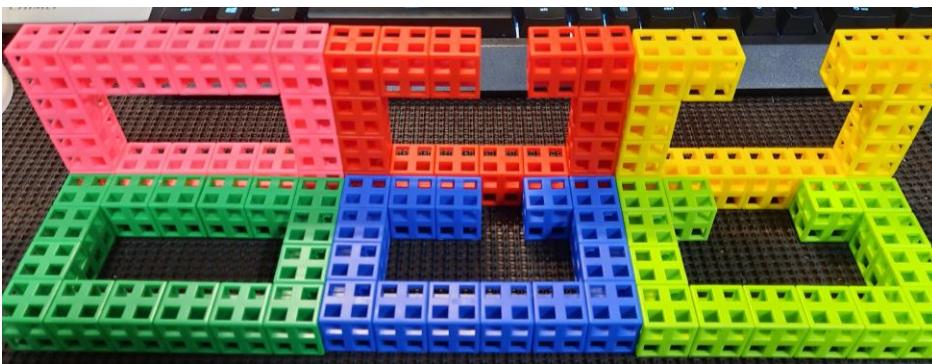
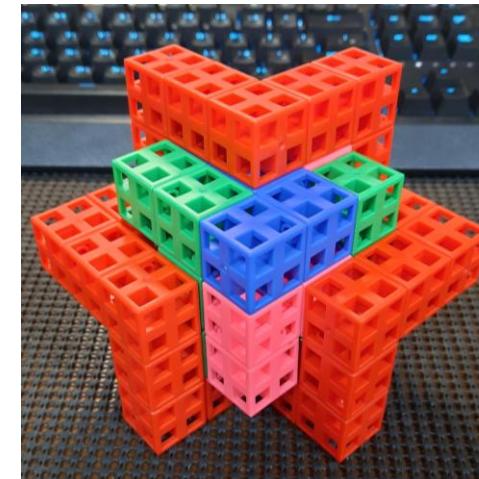
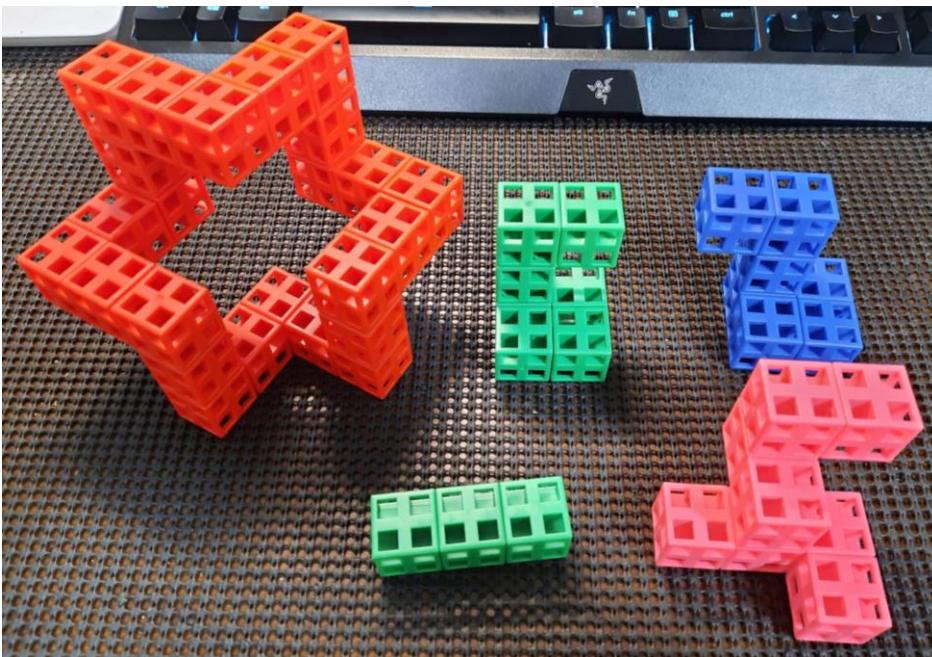
◆ 經典索瑪方塊 ( SOMA Cube ) :



◆ 組木展示：



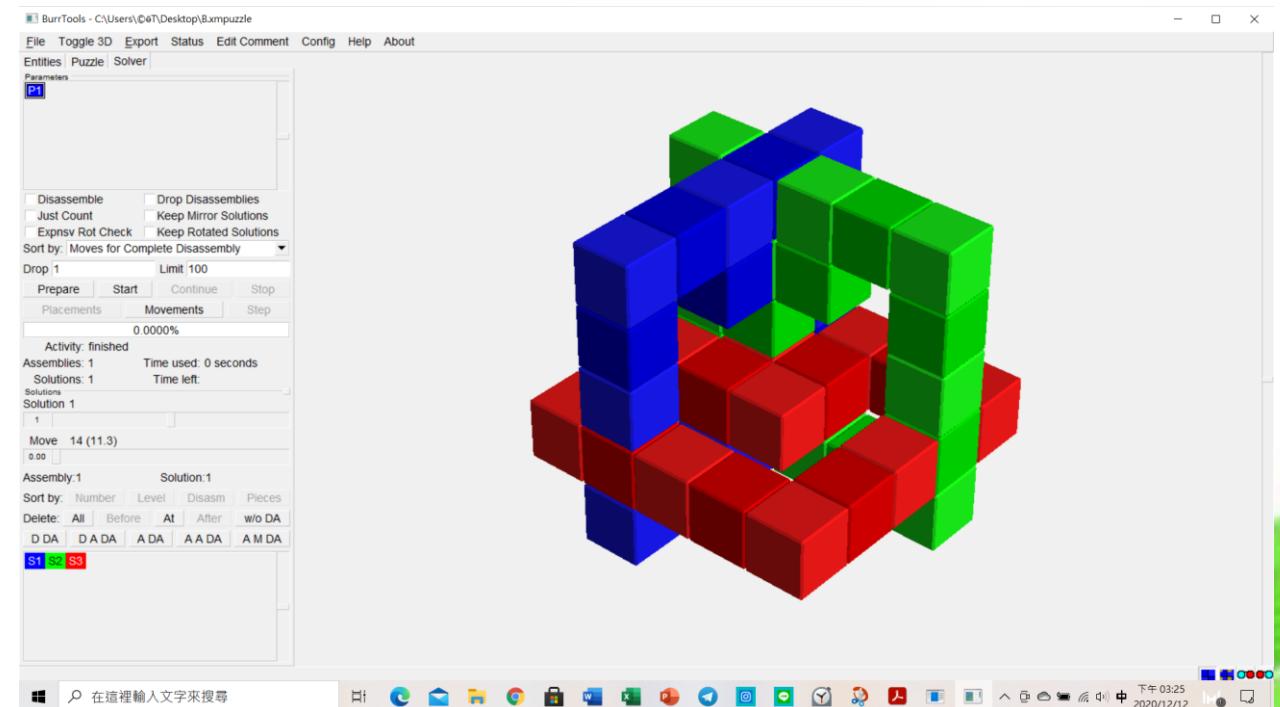
◆ 組木展示：



# 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 screenshot shows a Google search results page with the query "burr tools download". A red box highlights the search bar. A large red box on the right contains the text "1.搜尋「Burrtools download」". Below the search bar, there are filter options: 全部, 圖片, 新聞, 地圖, 影片, 更多. To the right are 設定 and 工具 buttons. The search results indicate approximately 8,400,000 results found in 0.42 seconds. The first result is a link to "Burr-Tools download | SourceForge.net", which is highlighted with a red box. This result includes a brief description, a 5-star rating with 5 reviews, and a link to "burrtols.sourceforge.net". A second red box on the right contains the text "2.點選".

g burr tools download - Google

google.com/search?q=burr+tools+download&oq=Burr-Tools&aq=chrome.3.69i57j0i30l5j69i61l2.1437j0j4&sourceid=chrome&ie=UTF-8

應用程式 高師網站 YouTube 林承俊 @ MixerBox Malody - Charts 薦均承 Chun-Chen... HTML Tutorial 陳仁純 (Chen, Ren... 昌爸工作坊--李信...

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**

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

★★★★★ 評分 : 5 · 5 票 · 免費 · 遊戲

burrtols.sourceforge.net ▾ 翻譯這個網頁

**Burr Tools**

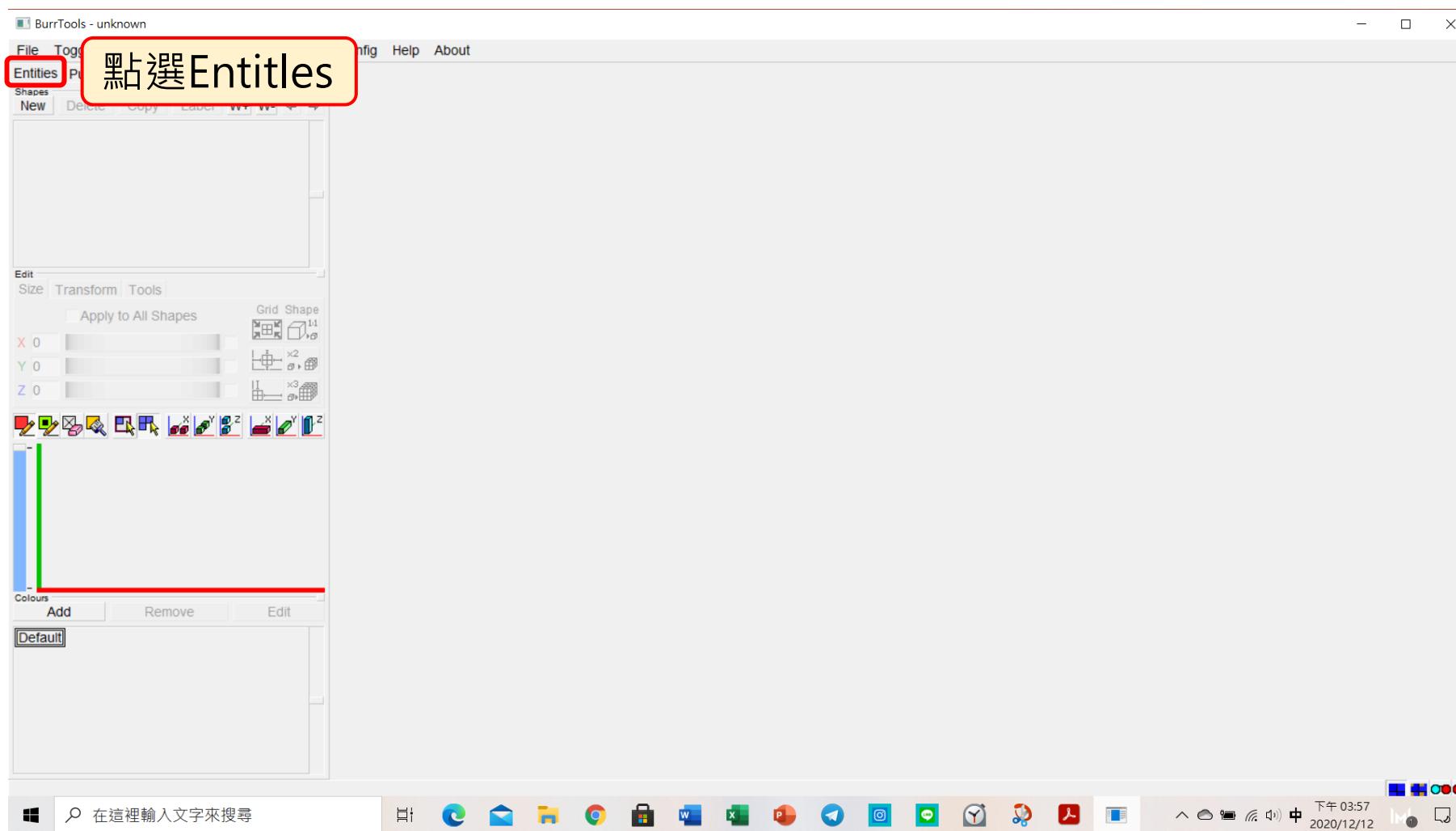
**Burr Tools.** This (set of) program(s) will help you solve a certain kind of puzzle. ... documentation is also available as a PDF below in the [download](#) section and ...

您於 2020/12/10 造訪這個網頁。

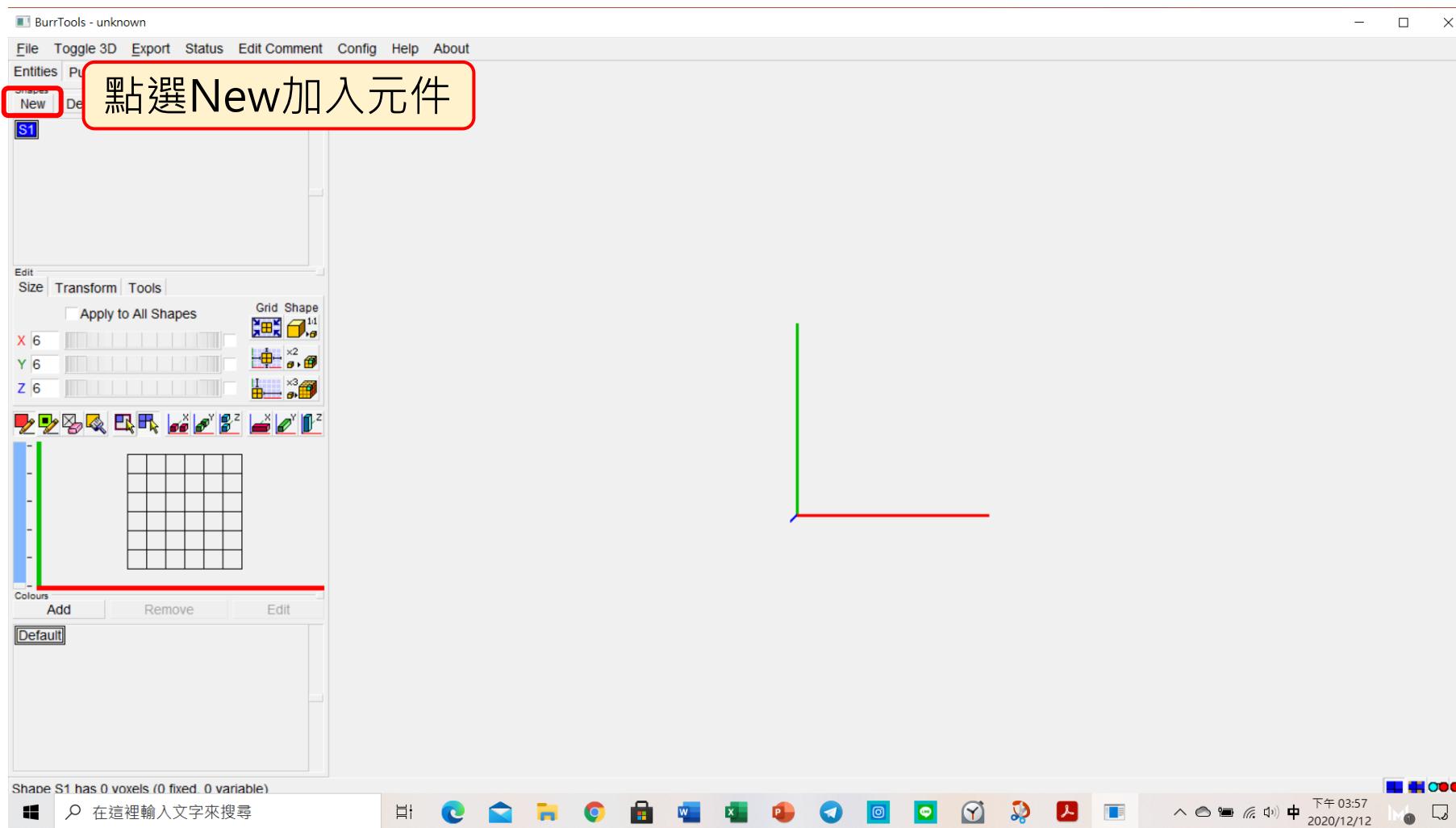
## ◆ Burrtools軟體取得

The screenshot shows a web browser window displaying the SourceForge project page for 'Burr-Tools'. The URL in the address bar is [sourceforge.net/projects/burrtools/](https://sourceforge.net/projects/burrtools/). The page features a dark header with the SourceForge logo and navigation links for 'Open Source Software', 'Business Software', and 'Resources'. A large banner in the center reads '大千 78-108 坪' (Taiwanese Chinese characters) with the English text 'the legacy palace' below it. Below the banner, the project title 'Burr-Tools' is displayed with a diamond icon, followed by the text 'Brought to you by: roever'. A review section shows a 5-star rating and '5 Reviews'. To the right, it says 'Downloads: 67 This Week'. A prominent green 'Download' button is highlighted with a red border. A red box with the text '3. 下載後並解壓縮即可' (3. Download and extract) is overlaid on the bottom right of the download button. At the bottom of the page, there are links for 'Windows', 'BSD', and 'Linux', along with tabs for 'Summary', 'Files', 'Reviews', 'Support', and 'Wiki'.

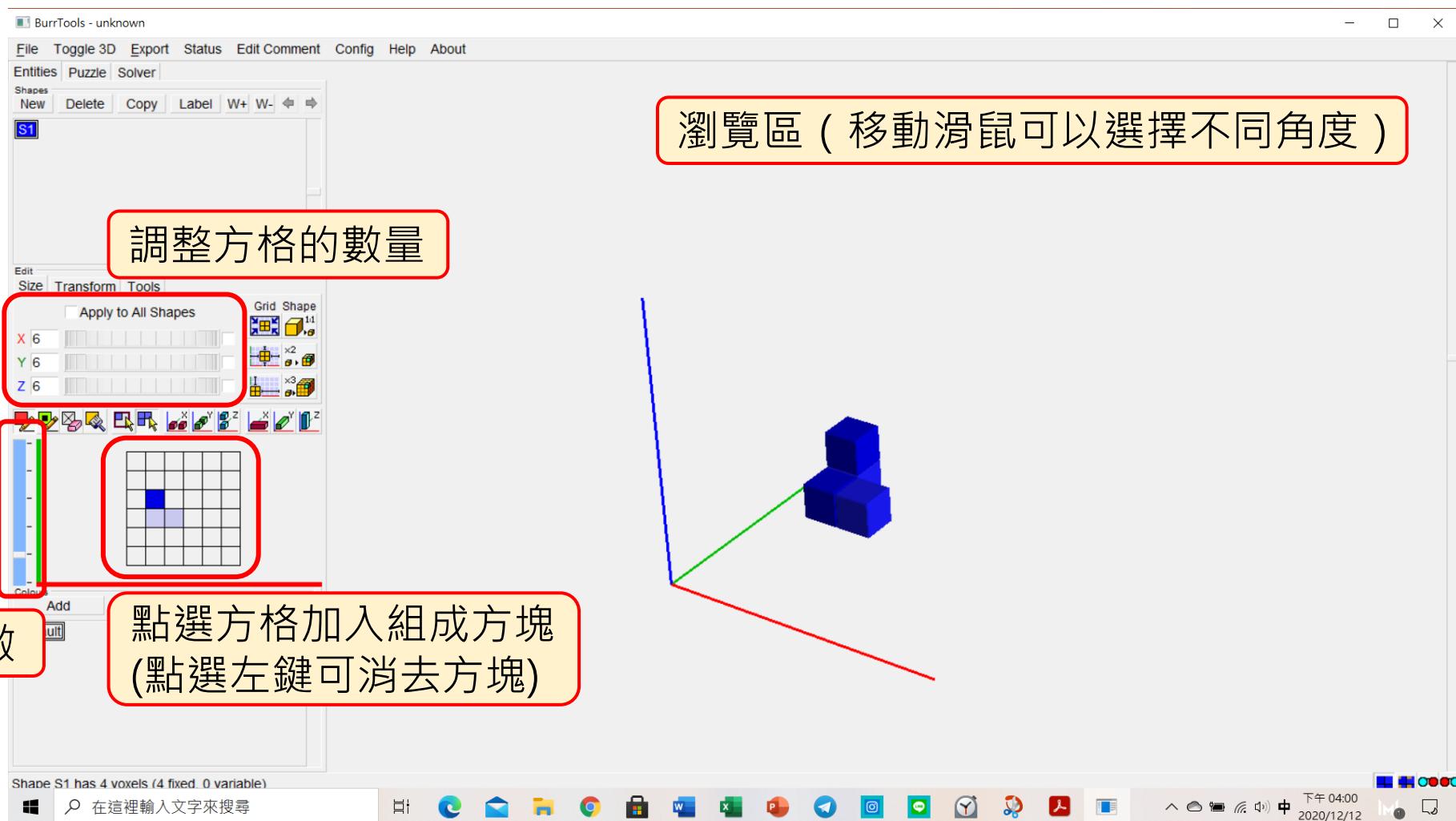
## ◆ 基本建構組木與解決其問題



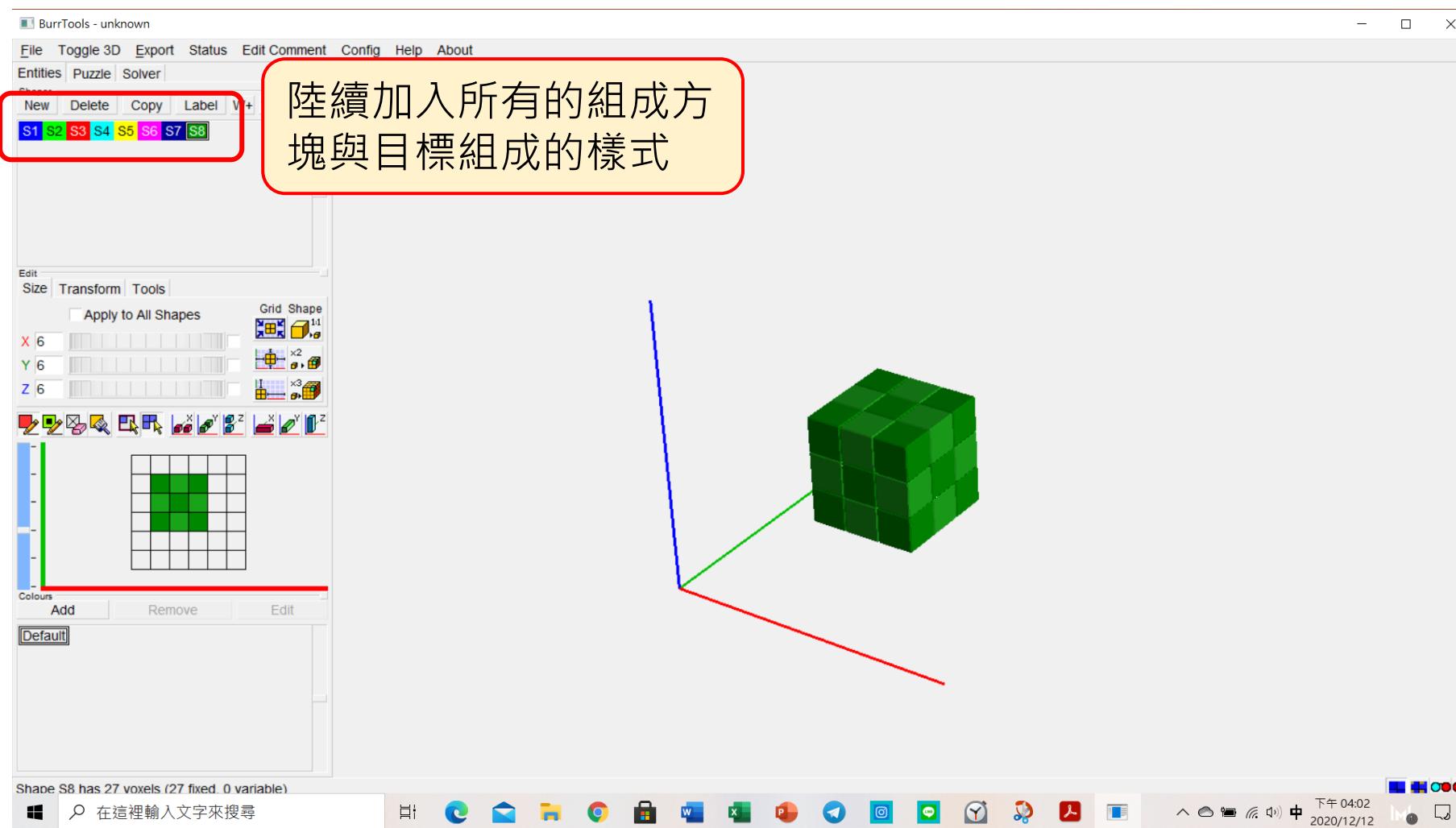
## ◆ 基本建構組木與解決其問題



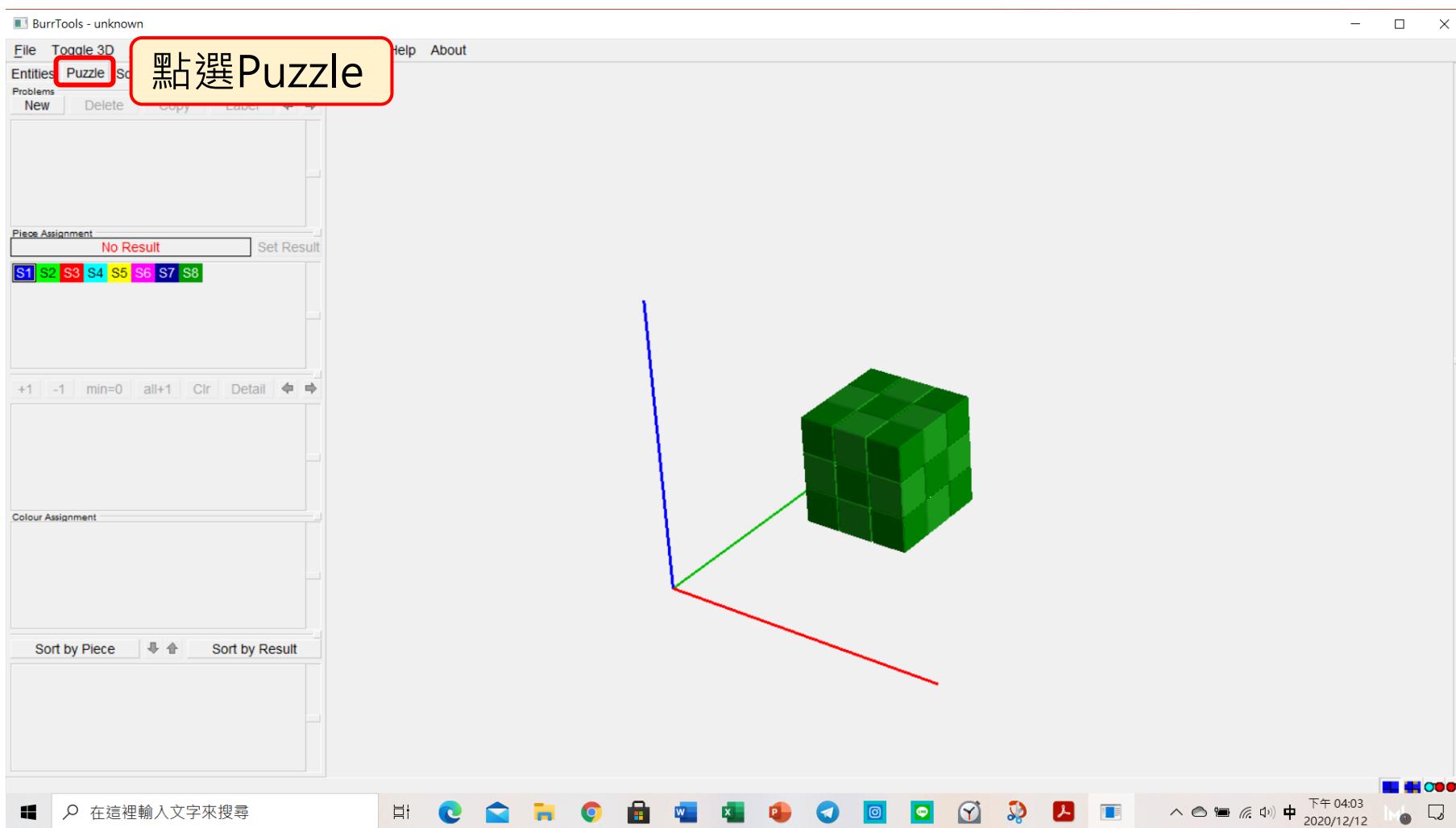
## ◆ 基本建構組木與解決其問題



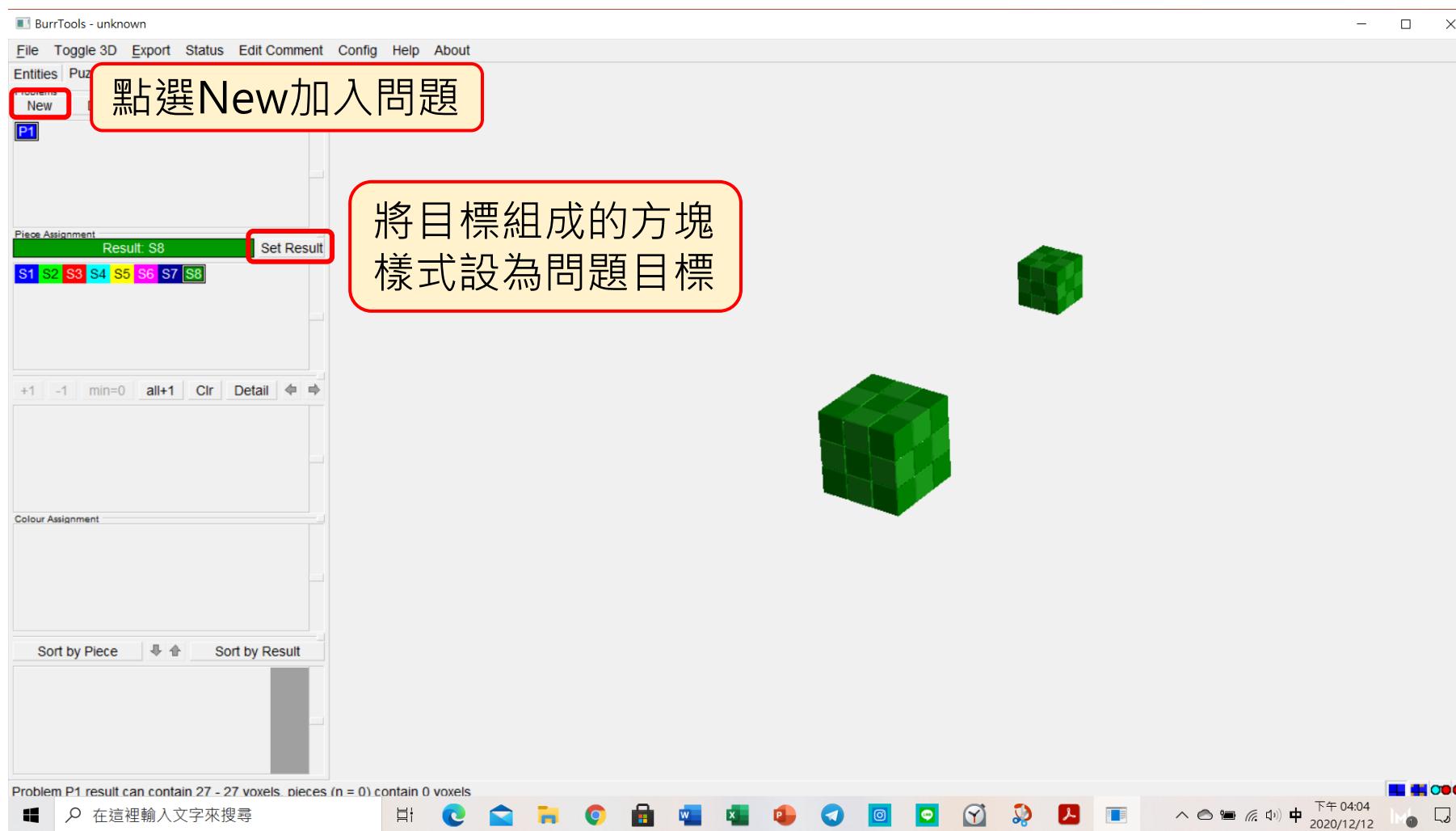
## ◆ 基本建構組木與解決其問題



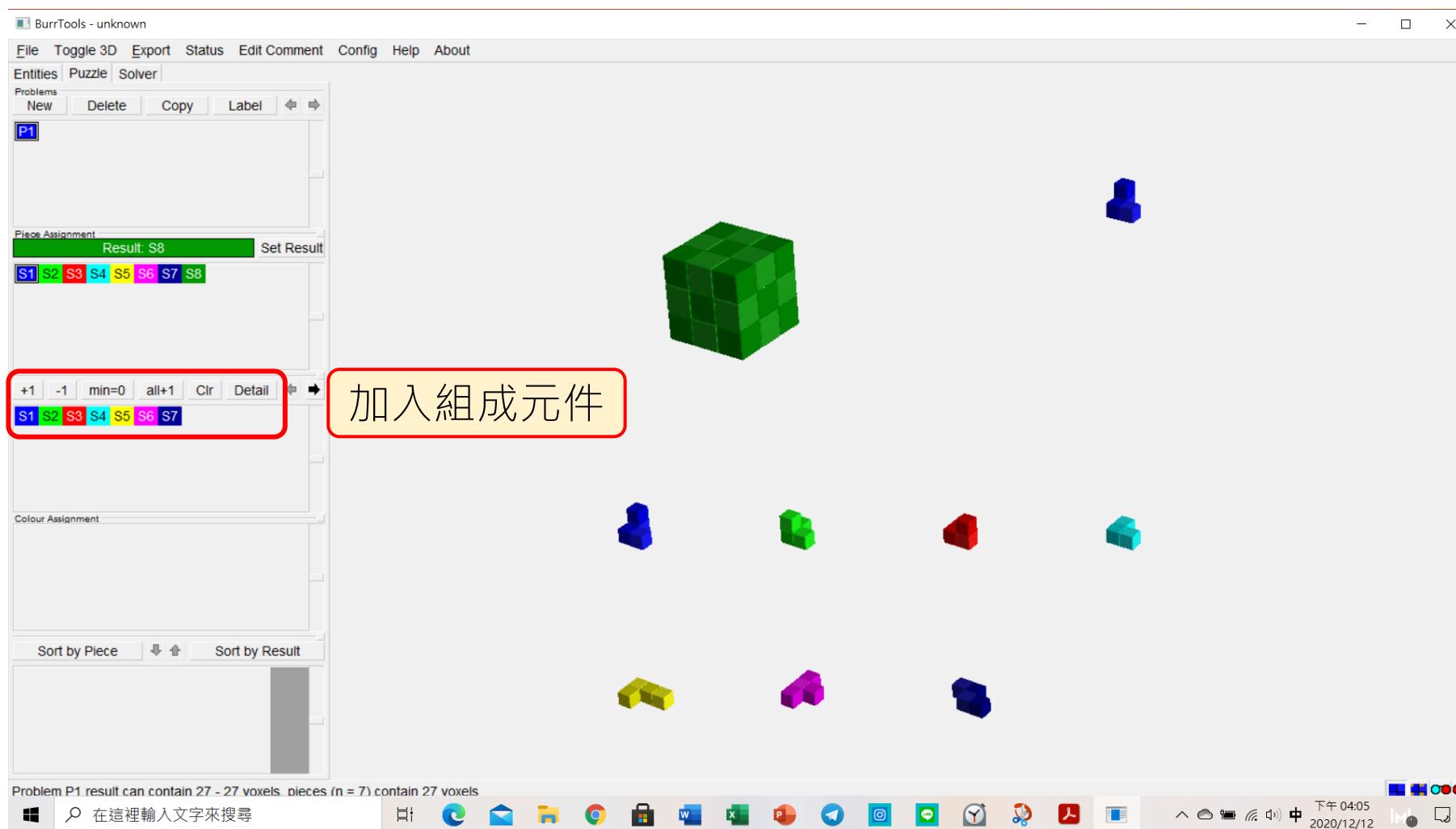
## ◆ 基本建構組木與解決其問題



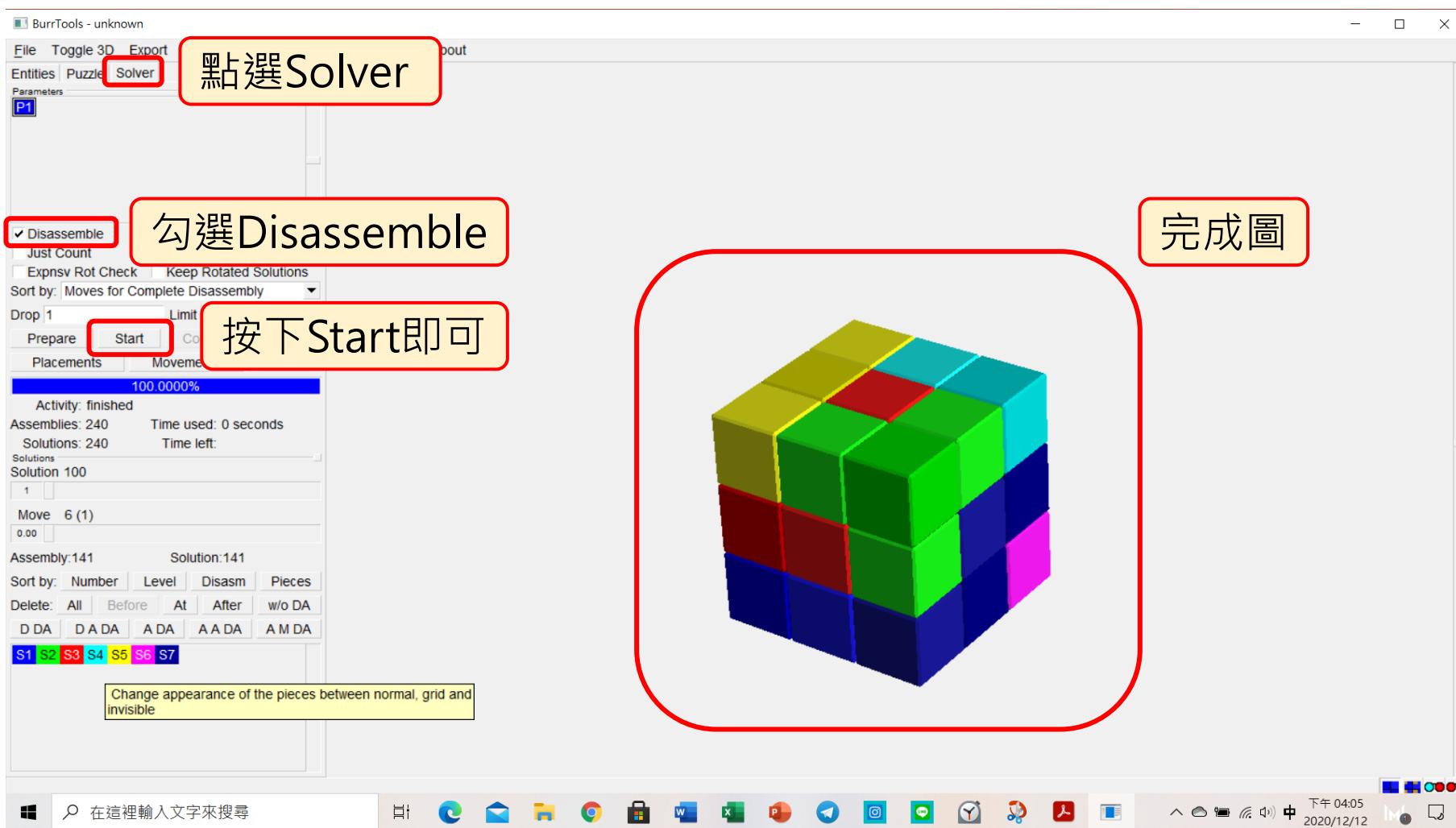
## ◆ 基本建構組木與解決其問題



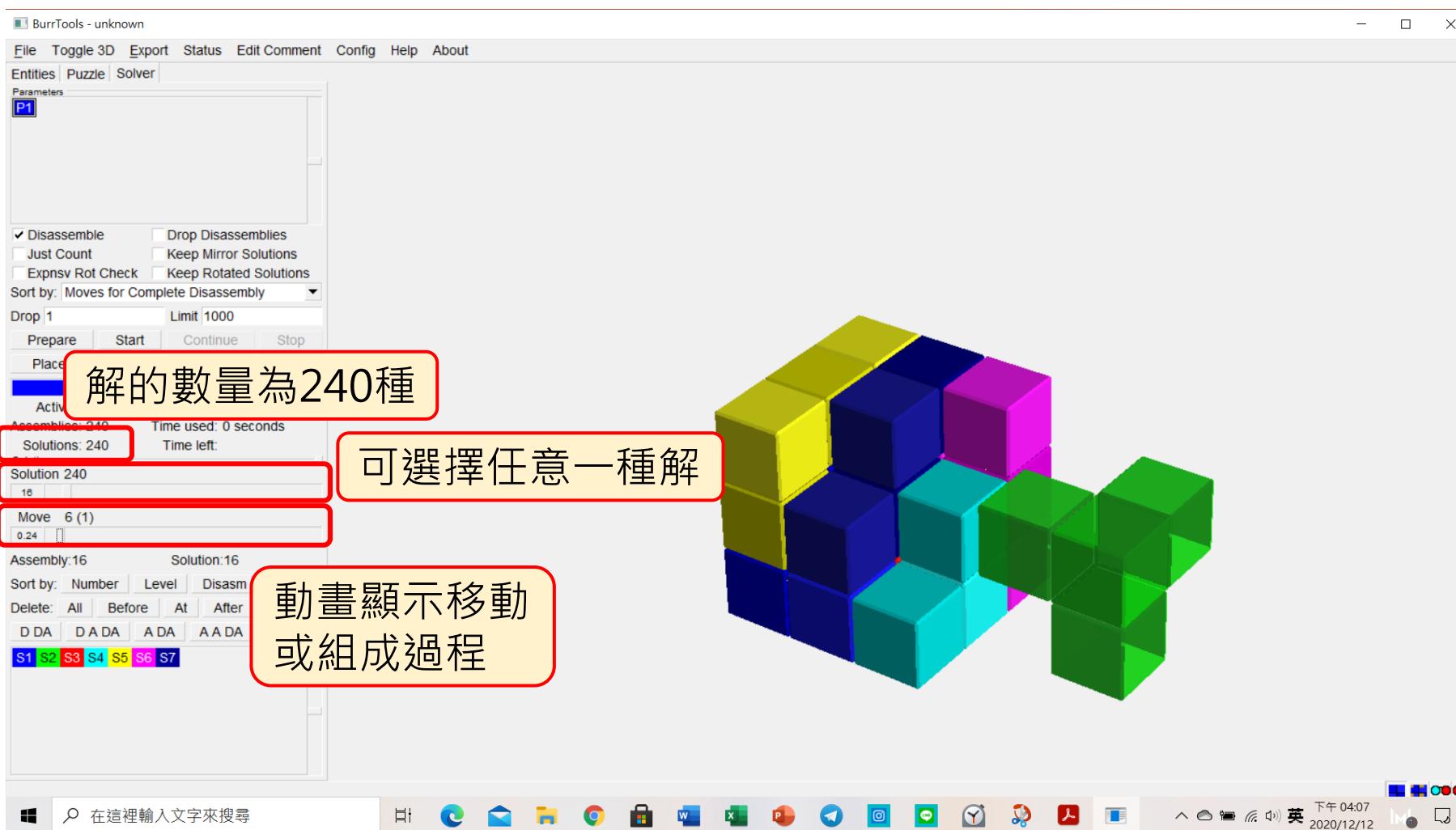
## ◆ 基本建構組木與解決其問題



## ◆ 基本建構組木與解決其問題



## ◆ 基本建構組木與解決其問題



## ◆ Voxel介紹

- Burrtools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

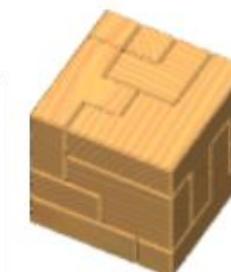
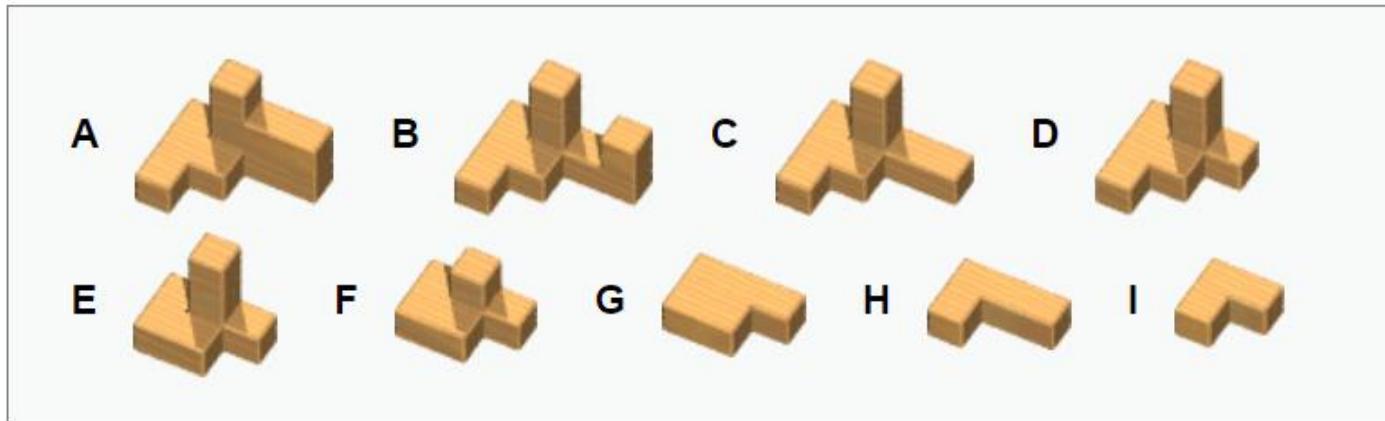


## ◆ Voxel介紹

### Void!

10 

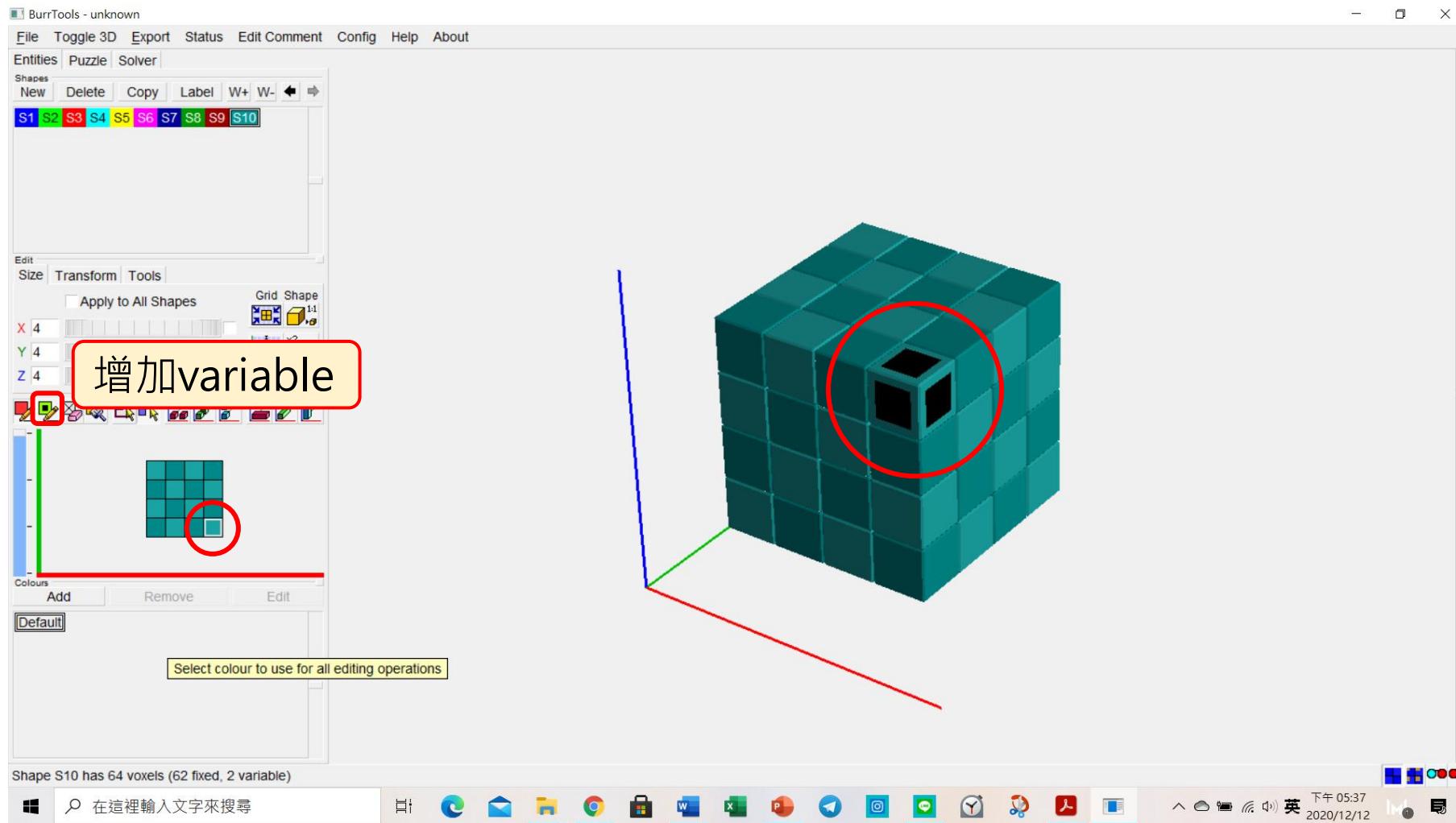
Design and Copyright : [László Molnár](#) (2018).



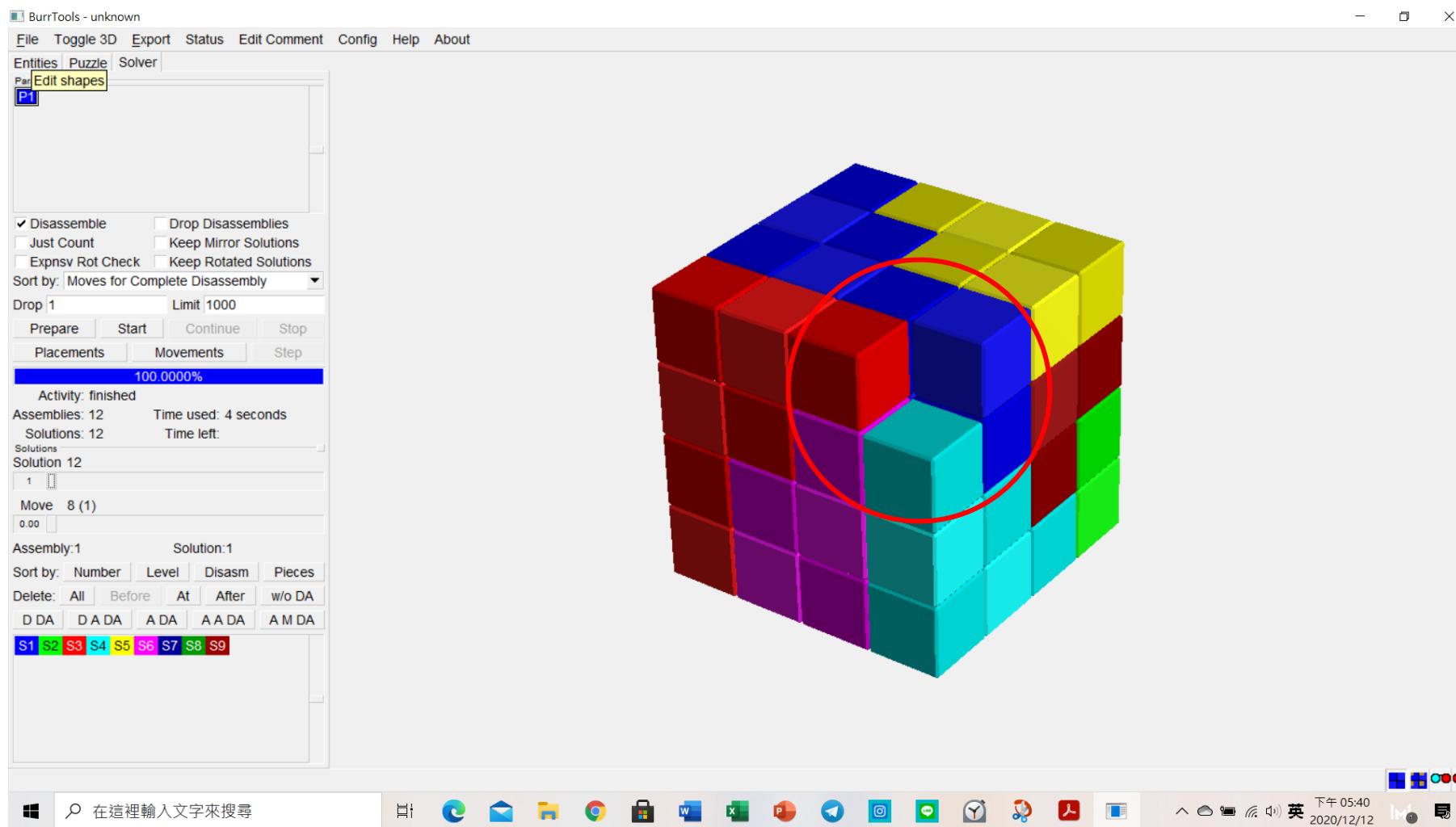
Pieces	9
Goal	4×4×4
Holes	1
Solutions	1
	Inside Hole.
	10 Outside Hole.



## ◆ Voxel介紹



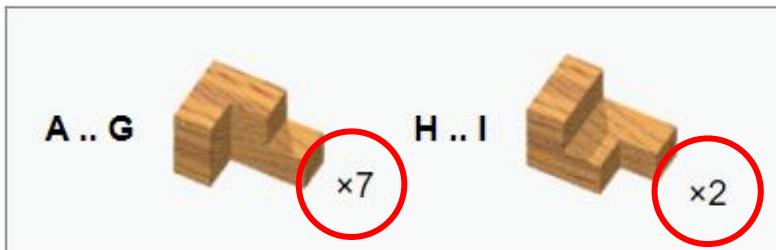
## ◆ Voxel介紹



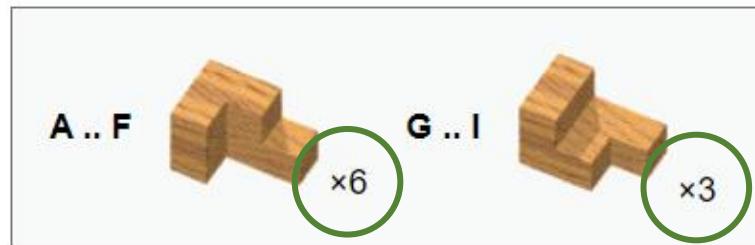
## ◆ 組成單元之數量條件變化

### Booties

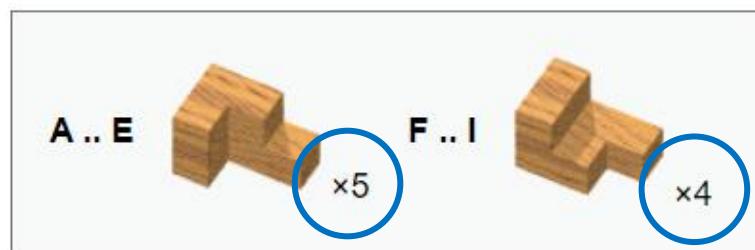
Design and Copyright : [Bram Cohen](#) (2011). [Unhappy Woodworm 2](#)



Pieces      9      **A-G, H-I** are congruent.  
Goal       $4 \times 4 \times 4$   
Holes      1  
Solutions      1



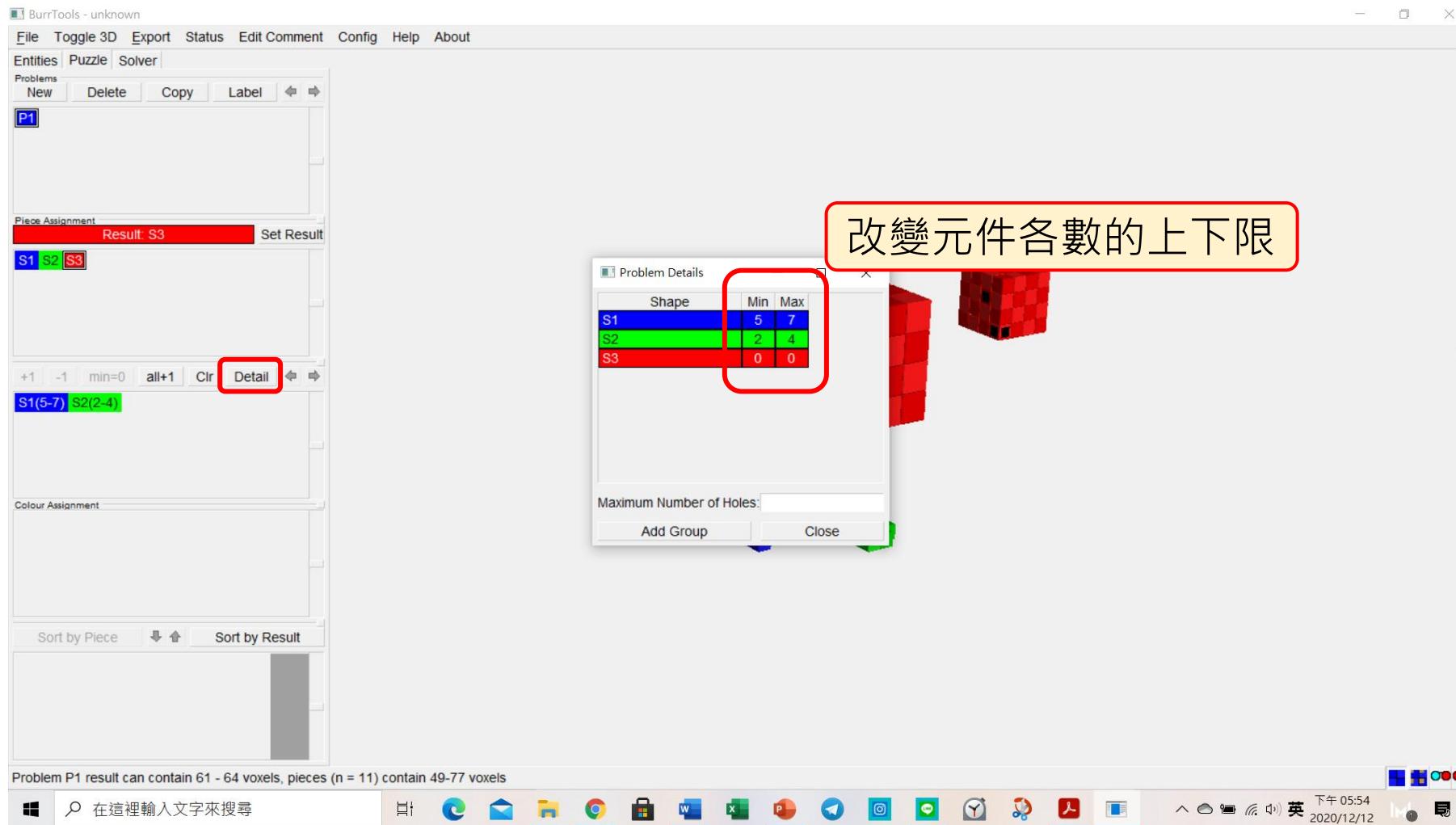
Pieces      9      **A-F, G-I** are congruent.  
Goal       $4 \times 4 \times 4$   
Holes      1  
Solutions      1



Pieces      9      **A-E, F-I** are congruent.  
Goal       $4 \times 4 \times 4$   
Holes      1  
Solutions      1



## ◆ 組成單元之數量條件變化



### 三、Burrttools實際操作應用



# 四、著名例子介紹&延伸探究

## ◆ 槿卯工藝（木工工藝）



▲平板明榫角結合



▲平板明榫角結合



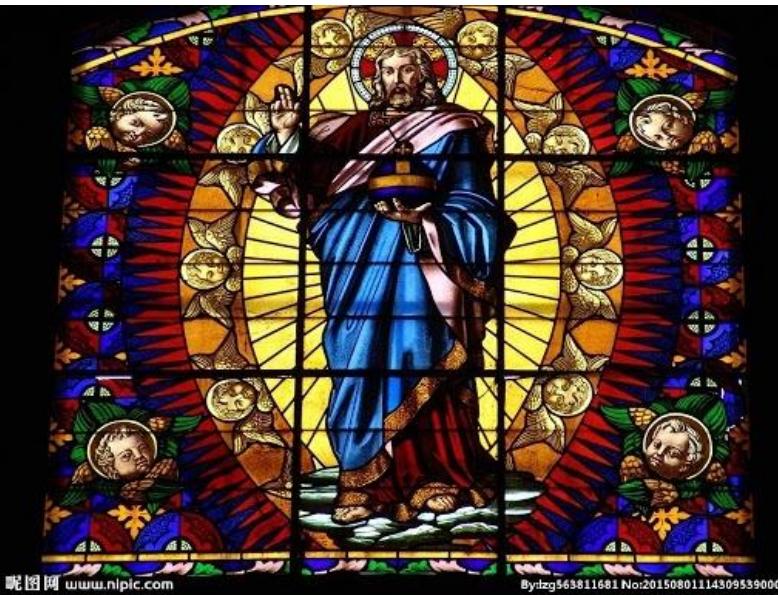
▲楔釘榫



## ◆ 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

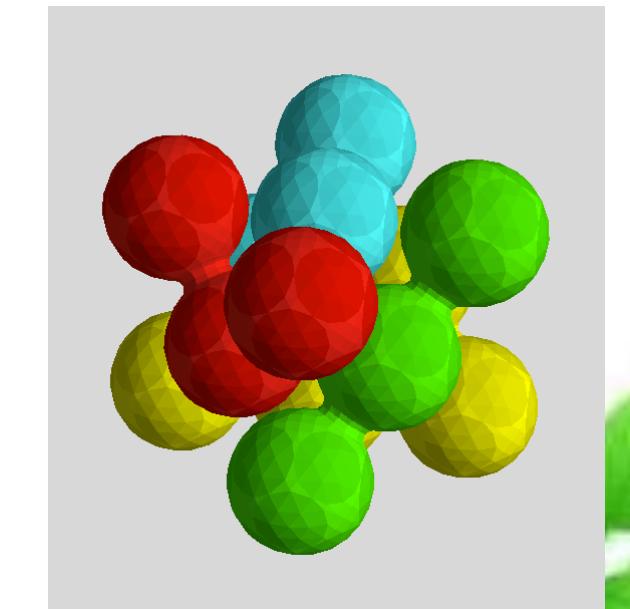
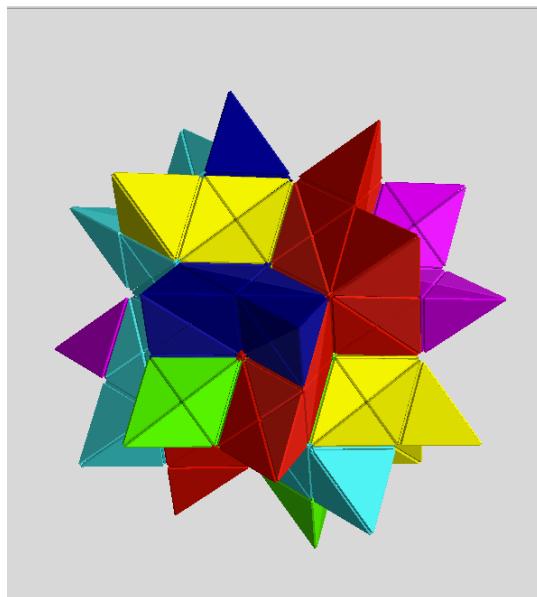
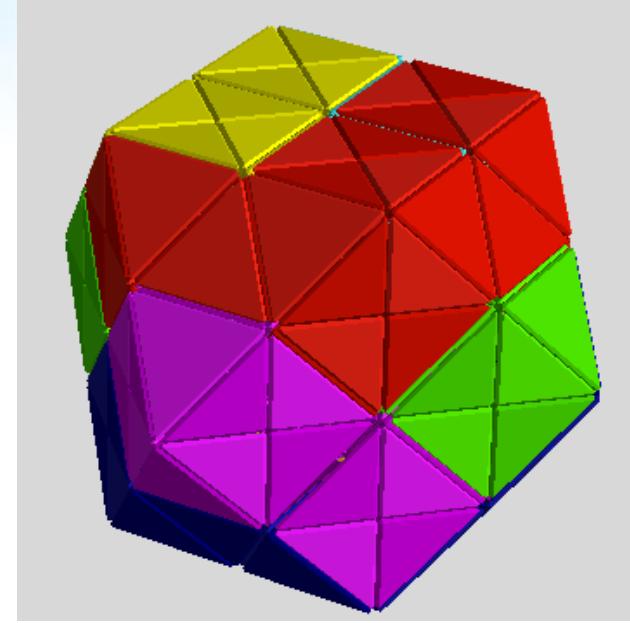
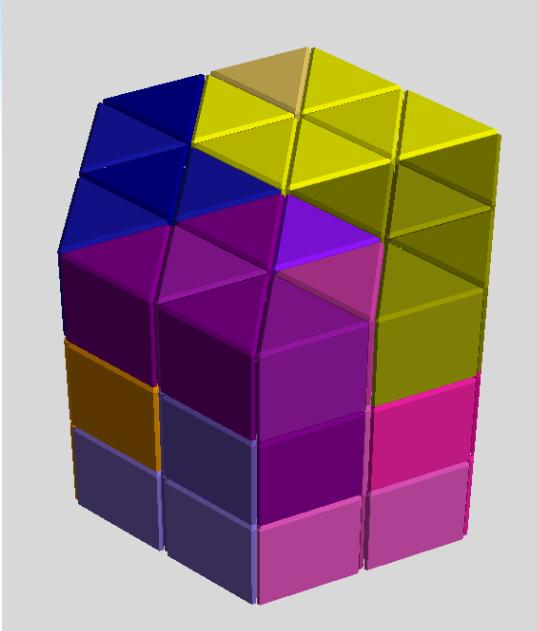
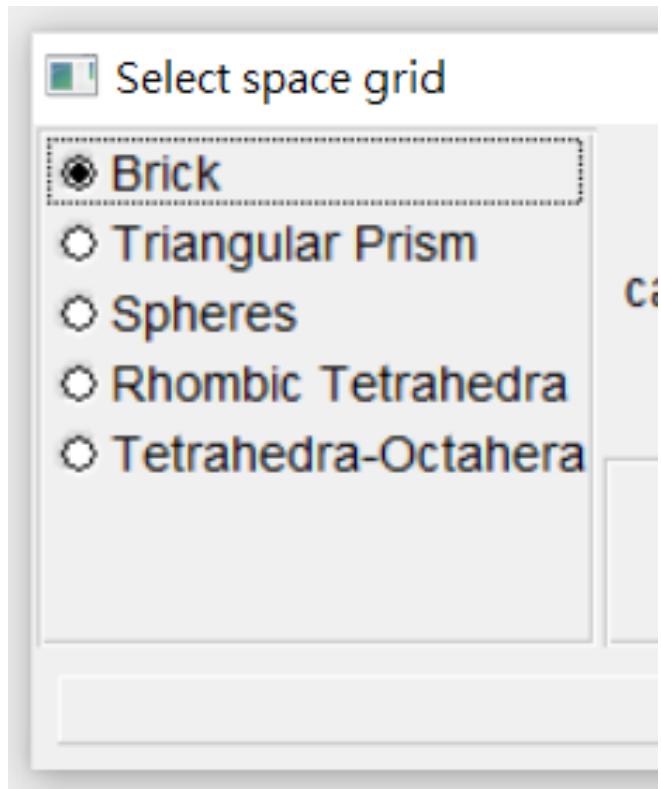


▲ 魯班鎖

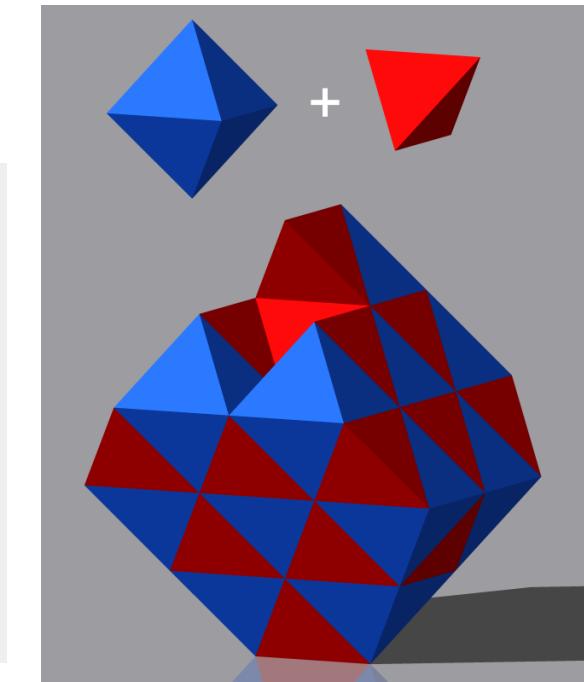
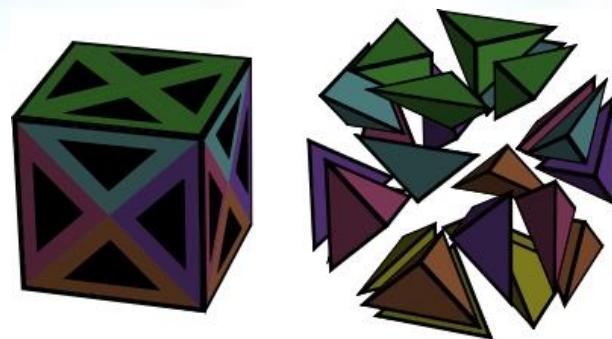
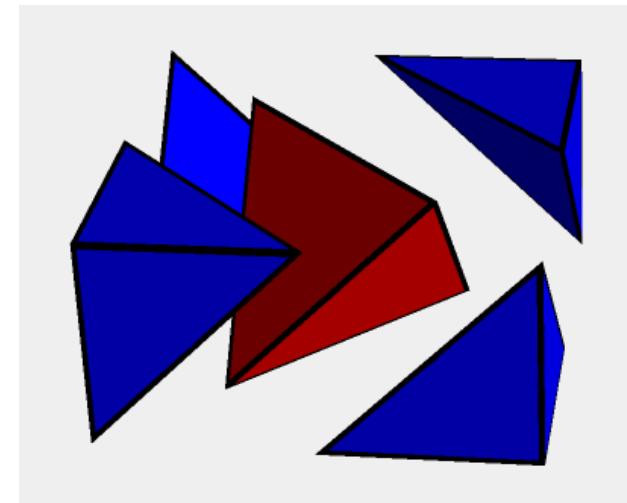
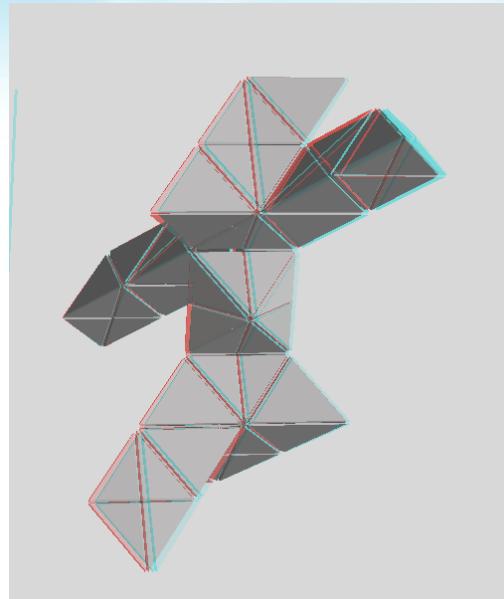
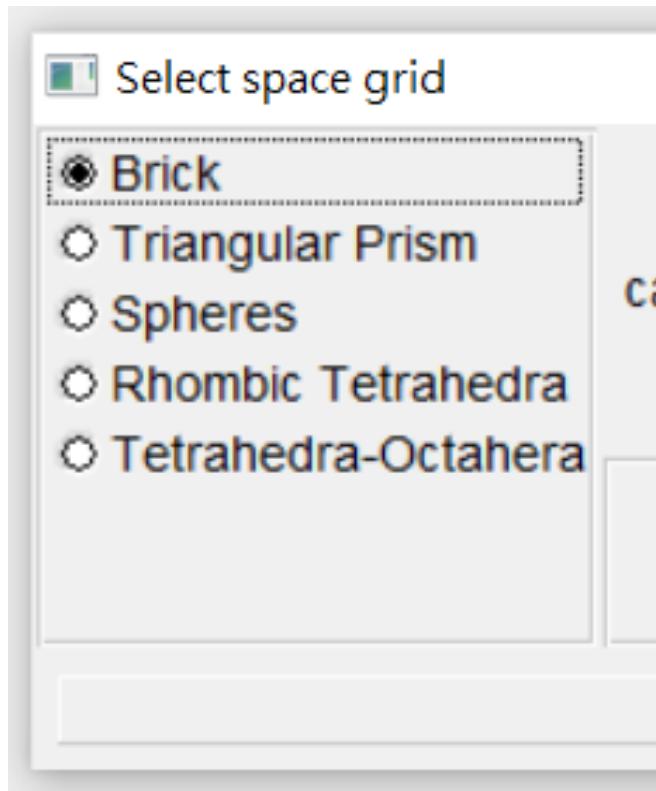


▲ 魯班盒

## ◆ 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。



# 參考資料

1. [https://en.wikipedia.org/wiki/Solomon\\_W.\\_Golomb](https://en.wikipedia.org/wiki/Solomon_W._Golomb)
2. [http://burrtools.sourceforge.net/gui\\_doc/Spacegrids.html](http://burrtools.sourceforge.net/gui_doc/Spacegrids.html)
3. <http://puzzlewillbeplayed.com/index.html.en>
4. <http://burrtools.sourceforge.net/>
5. 高師大數學系 美數學創社 數學玩具活動講義
6. <https://www.youtube.com/watch?v=6UbtwJpaA8A&t=178s>
7. <https://www.youtube.com/watch?v=gWEIYiOegFQ>
8. <https://youtu.be/fbaSLbDOCjs>



謝謝聆聽

