

高雄市 115 年度第 45 屆國民中小學科學園遊會
高雄市鳳山區中正國小

Kaohsiung Primary and Junior High Schools Science Lawn Party
Kaohsiung Fengshan District Zhongzheng Elementary School

不紙如此：循環「紙」數爆表！
More Than Paper : Circular & Stronger!

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一、活動主旨 Activity Objectives

本活動以日常生活中常見的「紙」為主題，設計一系列趣味性與科學性兼具的闖關活動，讓學生在動手操作的過程中，體驗科學原理如何與生活材料結合。透過三個關卡，學生將動手操作，使一張普通的紙能夠撐起巨大的重量、了解力在紙上的作用，以及生活中實際運用到這些原理的實例。活動除了強調動手實驗與觀察，也融入科學探究方法，鼓勵學生發問、比較與討論，讓他們能將科學知識與生活經驗相連結。期望學生在參與過程中，不僅能獲得有趣的學習體驗，也能激發對環境保護與資源再利用的重視，進一步思考如何將科學應用於日常生活。

This activity focuses on paper, a material commonly found in our everyday lives, and features a series of engaging and science-based challenges. Through hands-on exploration, students experience how scientific principles can be applied to everyday materials.

Through three interactive challenges, students will experiment with ways to make a single sheet of ordinary paper support a surprisingly large amount of weight, explore how forces act on paper, and discover real-life examples of how these scientific principles are applied in everyday situations.

In addition to emphasizing hands-on experimentation and observation, the activity incorporates scientific inquiry by encouraging students to ask questions, make comparisons, and engage in discussion. Through these experiences, students are encouraged to connect scientific knowledge with their everyday experiences.

The activity aims not only to provide students with an enjoyable and meaningful learning experience, but also to foster greater awareness of environmental protection and resource reuse. Ultimately, students are encouraged to think about how scientific knowledge can be applied to solve problems and improve everyday life.

二、名詞解釋 Definition of terms

1、截面二次矩：Second Moment of Area

「截面」就是把紙柱橫著切開後，從切面看到的形狀。截面二次矩可以用來描述截面的形狀與尺寸對抗彎曲的影響。同樣是一張紙，平平地放著時很容易彎曲；捲成紙筒後，紙張形成圓形的結構，截面形狀改變，因此抵抗彎曲的表現也會改變。

A cross-section is the shape we see when a paper column is cut horizontally across its width. The second moment of area describes how the shape and size of a cross-section affect its resistance to bending.

2、抗彎剛度：Flexural Rigidity

一個結構容不容易彎曲，不只跟「它是什麼材料」有關，也跟「它長什麼形狀」有關。抗彎剛度可以幫助我們了解結構抵抗彎曲變形的能力。

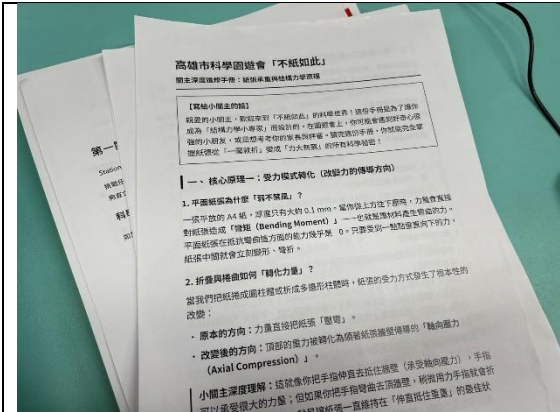
Whether a structure bends easily depends not only on what material it is made of, but also on its shape and design. Flexural rigidity helps us understand a structure's ability to resist bending and deformation.

3、歐拉屈曲：Euler Buckling

當重量放到直立紙柱上時，紙柱不一定會直接被壓扁。有時候它會先出現一點點彎曲，接著越來越不穩定，最後突然向旁邊彎倒。這種因為受壓而失去穩定、向側面彎曲的現象，就叫做「屈曲」。

When a heavy weight is placed on a standing paper column, the column may not simply get squashed. It may first bend a little, then become less stable, and suddenly bend and fall to one side. This happens when a structure loses its stability under pressure and bends to the side. This is called “buckling” .

三、材料準備

	
廢 A4 紙	膠帶
	
平板電腦	

四、 關卡活動 Challenge activity

1、 變形紙巨人 Paper Giant

要在 3 分鐘內，只使用一張 A4 紙，想辦法讓重物可以離開桌面 5 秒鐘以上，而且越遠越好！（完成後不能用手扶住紙或重物）

原理：我們發現做成圓柱狀最能承受重量。

1. 捲成圓筒後，上方的壓力會沿著圓形的弧度均勻傳遞到整周的紙壁上，沒有單一的脆弱施力點。

2. 紙的支撐力慣性矩有關，慣性矩越大越不容易彎曲。將紙變成立體的之後，慣性矩會變大，紙就更不容易變彎。

You have 3 minutes and one sheet of A4 paper. Your goal is to make a structure that can hold a heavy object at least 5 seconds while keeping the object as far away from the table as possible!

Once the challenge is complete, you cannot use your hands to hold the paper or the object.

How Does It Work?

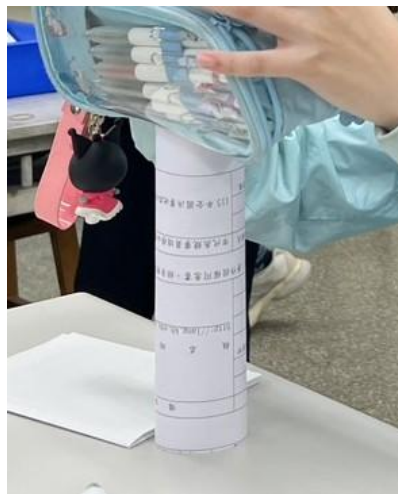
We found that making the paper into a cylinder is one of the best ways to support weight.

Spreading the force

When the paper is rolled into a tube, the weight on top is spread around the curved wall of the tube. The force is not concentrated on just one weak spot.

Making the paper harder to bend

The paper's ability to resist bending depends on its moment of inertia. A larger moment of inertia makes a structure harder to bend. When a flat sheet of paper is made into a 3D shape, its moment of inertia becomes larger, making the paper stronger and harder to bend.



圖一

2、綠色建築師 Green Architect

生活中有許多運用立體的紙來承載重物的例子，例如紙箱中間的波浪結構、紙做的椅子、甚至建築物的柱子都有用紙做出來的！所以當有廢紙時千萬不要亂丟，一定要將它回收再利用！

There are many examples of using 3D paper structures to carry heavy loads in our daily lives. For example, cardboard boxes have a wavy layer in the middle to make them stronger. Paper can even be used to make chairs and columns for buildings!

So, when you have used paper, don't just throw it away! Be sure to recycle and reuse it whenever possible.



圖二



圖三

五、 結果與討論 Discussion and Conclusion

學生將可在此活動中，發現：

- 1、**形狀會影響結構強度**：學生會發現，同樣是一張 A4 紙，透過捲成圓柱、改變紙張形狀或增加結構，就能產生不同的承重能力。學習到形狀、結構與承重能力之間的關係，建立初步的工程與結構概念。
- 2、**培養問題解決與工程設計能力**：第一關只有一張紙與有限時間，學生必須不斷嘗試：「怎麼折？怎麼捲？哪種形狀比較穩？」失敗後再修改設計，最後找出能承重的方法。培養觀察、嘗試、修正與解決問題的能力，也就是工程設計中常見的「試作—測試—改良」歷程。
- 3、**將生活中的科學原理與實際物品連結**：第二關從紙椅延伸到瓦楞紙箱、南投紙教堂，讓學生發現課堂上的「紙張結構」並不是只有遊戲，而是實際應用在生活與建築中的工程技術。建立「生活中的物品也有科學原理」的概念。
- 4、**建立永續設計與資源利用的概念**：活動以一張紙為材料，讓學生思考「如何用更少的材料達到足夠的強度」，再延伸到減少浪費與材料再利用。培養珍惜資源、減少材料浪費及永續設計的觀念。

期許這些學習成果不僅能增強他們的科學素養，還能激發對學習的興趣與熱情。

Through this activity, students will discover:

1. Shape affects the strength of a structure

Students will discover that the same sheet of A4 paper can support different amounts of weight by rolling it into a cylinder, changing its shape, or adding different structures. They will learn about the relationship between shape, structure, and load-bearing ability, and develop a basic understanding of engineering and structures.

2. Developing problem-solving and engineering design skills

In the first challenge, students have only one sheet of paper and a limited amount of time. They must keep asking questions such as, “How should I fold it?” “How should I roll it?” and “Which shape is more stable?” After each failed attempt, they can change and improve their design until they find a way to support the weight. This process helps develop skills in observing, trying, testing, improving, and solving problems—an important part of the engineering design process.

3. Connecting science in everyday life with real-world objects

The second challenge connects the paper chair to real-world examples such as corrugated cardboard boxes and the Paper Dome in Nantou. Students will discover that the “paper structures” they explore in the activity are not just games, but are also used in real-life engineering and architecture. They will develop the idea that everyday objects can be designed and built using scientific principles.

4. Developing ideas about sustainable design and resource use

Using just one sheet of paper as the main material encourages students to think about how to use less material while still achieving enough strength. They can then connect this idea to reducing waste and reusing materials. Through this experience, students will develop an understanding of saving resources, reducing material waste, and sustainable design.

It is hoped that these learning outcomes will not only enhance their scientific literacy but also spark greater interest and enthusiasm for learning.

六、未來貢獻 Future contribution

本活動透過「一張紙也能承重」的實作挑戰，引導學生從生活中的材料出發，探索形狀、結構與功能之間的關係，並透過「嘗試—測試—修正」的歷程，培養科學探究、創意思考及問題解決能力。學生在活動中不僅學習科學原理，更能將所學延伸至生活中的紙箱、紙椅及建築結構，建立將科學知識應用於真實情境的能力。

活動同時融入永續發展理念，透過「以較少材料創造較大功能」的概念，引導學生思考材料使用、資源節約、再利用與減少浪費的重要性，逐步建立永續設計與負責任消費的觀念。

本活動呼應聯合國永續發展目標（SDGs）：

SDG 4 優質教育：培養學生探究、創新、問題解決及永續發展所需的能力。

SDG 9 產業、創新與基礎建設：透過簡易工程設計活動培養創新思維與工程素養。

SDG 12 負責任的消費與生產：引導學生理解材料有效利用、減少浪費及再利用的概念。

期望學生透過此次活動，從「一張紙」看見科學與生活的連結，並將「善用資源、勇於創新、解決問題」的思維延伸至未來的學習與生活，逐步成為具備科學素養、創新能力與永續意識的學習者。

Through the hands-on challenge of “A Single Sheet of Paper Can Hold Weight,” this activity guides students to explore the relationship between shape, structure, and function using materials from everyday life. Through a process of trying, testing, and improving, students develop skills in scientific inquiry, creative thinking, and problem-solving. They not only learn scientific principles but also apply what they have learned to real-life examples such as cardboard boxes, paper chairs, and building structures. This helps them develop the ability to apply scientific knowledge to real-world situations.

The activity also incorporates the idea of sustainable development. By exploring how to create greater function with less material, students are encouraged to think about the importance of using materials wisely, saving resources, reusing materials, and reducing waste. Through this experience, they gradually develop an understanding of sustainable design and responsible consumption.

This activity aligns with the United Nations Sustainable Development Goals (SDGs):

SDG 4 – Quality Education:

Develops students' skills in inquiry, innovation, problem-solving, and sustainable development.

SDG 9 – Industry, Innovation and Infrastructure:

Develops innovative thinking and basic engineering skills through simple engineering design activities.

SDG 12 – Responsible Consumption and Production:

Helps students understand the importance of using materials efficiently, reducing waste, and reusing resources.

Through this activity, we hope students will see the connection between science and everyday life through “a single sheet of paper.”

We also hope they will carry the ideas of using resources wisely, being willing to innovate, and solving problems into their future learning and daily lives, gradually becoming learners with scientific literacy, innovative thinking, and an awareness of sustainability.

八、參 考 文 獻

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