

NEXT ENGINEERS

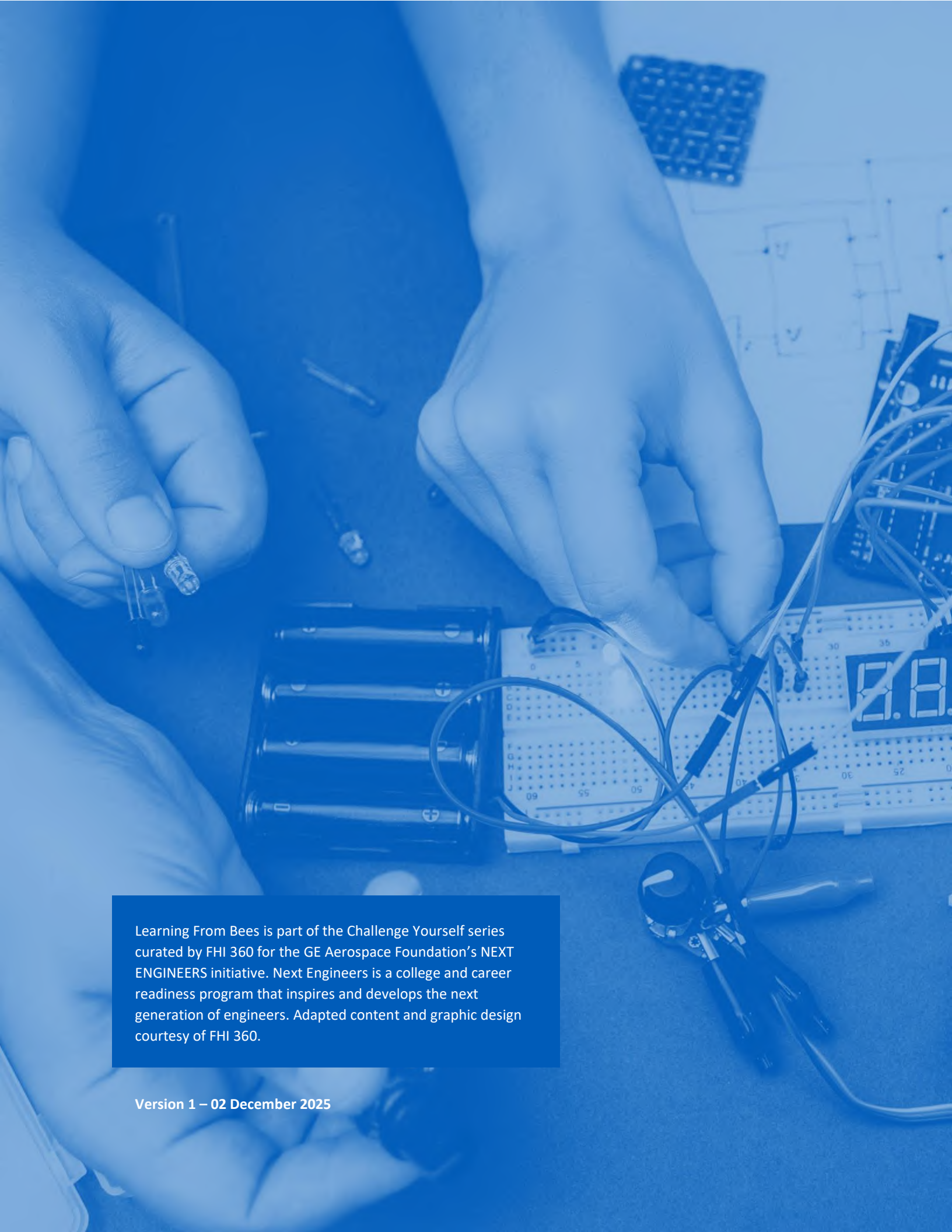


CHALLENGE YOURSELF

JWST Part 3: Learning From Bees Aerospace Engineering



NEXT ENGINEERS



Learning From Bees is part of the Challenge Yourself series curated by FHI 360 for the GE Aerospace Foundation's NEXT ENGINEERS initiative. Next Engineers is a college and career readiness program that inspires and develops the next generation of engineers. Adapted content and graphic design courtesy of FHI 360.

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The James Webb Space Telescope Part 3: Learning from Bees

NERD OUT

Building a Honeycomb

To capture the tiny amount of light emitted from the most distant parts of the universe, the James Webb Space Telescope needs a big mirror. Its mirror is 6.5 m (24 ft) high, about as high as a two-story building.

No mirror that large has even been made. With current technology, it would be impossible to properly shape and polish a mirror that large. Not only that, how do you get a 6.5 m mirror to fit into a rocket only 4.5 m wide?

The answer lies in making the primary mirror out of 18 separate hexagonal mirrors. Altogether, they create a mirror large enough and the three hexagons on either side can fold back making the mirror narrow enough to fit inside the rocket.



Folding wings of the Webb primary mirror

Image by NASA, Chris Gunn used under fair use

<https://webb.nasa.gov/content/observatory/ote/mirrors/index.html#1b>



DID YOU KNOW

Hexagons are one of the most efficient shapes to tessellate (to arrange in a repeated pattern without any gaps) because they have the greatest area for the smallest perimeter. For bees, that means more honey can be stored while using the least wax. For the James Webb Space Telescope, that means more mirror with less edge to be damaged.

Want to know more about why hexagons are so amazing? Watch *Hexagons are the Bestagons* (9:26) (<https://www.youtube.com/watch?v=thOifuHs6eY>)



In the image above, you can see one of the "wings" folded back. Each wing holds three mirror segments. When Webb launched, both wings were folded in this way, which allowed the mirror to fit into the rocket.

But why were hexagons chosen, besides of course that they are the best shape ever? They were chosen because, together, hexagons can make a mirror that is almost circular (the best shape for collecting and focusing light) without leaving any gaps between the pieces. If the segments were circular, there would be gaps between them which would be a waste of potential reflecting surface.

Here is a time-lapse video showing the assembly of the primary mirror: *The Assembly of the James Webb Space Telescope Primary Mirror* (1:24) (<https://www.youtube.com/watch?v=1d1sHLkmNQI>)

Using hexagons also means that the whole primary mirror is perfectly symmetrical, which makes focusing the light much simpler.

The exact orientation and shape of each mirror segment can be precisely controlled by seven motors. And by 'precisely' we mean movements less than a $1/10\,000^{\text{th}}$ the width of a human hair.

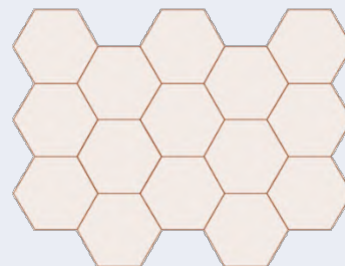
The video called *Webb Space Telescope Laser-Focused Sight* (1:13) (<https://www.youtube.com/watch?v=2zQiWEXTg4>) explains how the Webb will focus its primary mirror to capture clear shape images.

Explore more at *Webb Space Telescope* (<https://webbtelescope.org>).



HAVE A THINK

Here is a tessellation of regular hexagons.



Can you explain why regular hexagons tessellate?



GET ACTIVE

Build your own tessellation out of regular polygons using *The Tessellator* (<https://www.geogebra.org/m/rq4e52dd>).

Watch *The NRICH Tessellator* (3:34) (<https://www.youtube.com/watch?v=iAbRctkf8I0>) if you need help using the tool.

You can also draw your own tessellation on a piece of

