Hands-on Learning to Make Theory Reality - Experiential Learning for Aerospace Engineering

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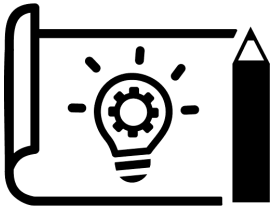
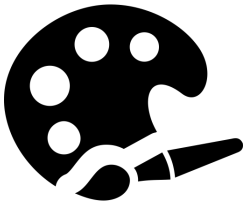


What was your favorite thing you made during your studies?

What did you learn?



Common experiences with experiential learning

Positives

- Improved learning retention
- Good educational experiences
- Increased technical learning (‘hard’ skills)
- Teamwork / connecting to others (‘soft’ skills)

Challenges

- Lack of scaffolding / guidance
- Support for equitable teamwork

Gittings, L., Taplin, R., & Kerr, R. (2020). Experiential learning activities in university accounting education: A systematic literature review. Journal of Accounting Education, 52, 100680.
Coker, J. S., Heiser, E., Taylor, L., & Book, C. (2017). Impacts of experiential learning depth and breadth on student outcomes. Journal of Experiential Education, 40(1), 5-23.

Skilling Laboratory @ Aeronautics & Astronautics

Makerspace / Laboratory

- Prototyping
- Laser cutting & 3D printing
- Soldering/electronics
- Flight simulators

Teaching space

- Supporting Aero/Astro classes & events

AA100: Introduction to Aeronautics and Astronautics

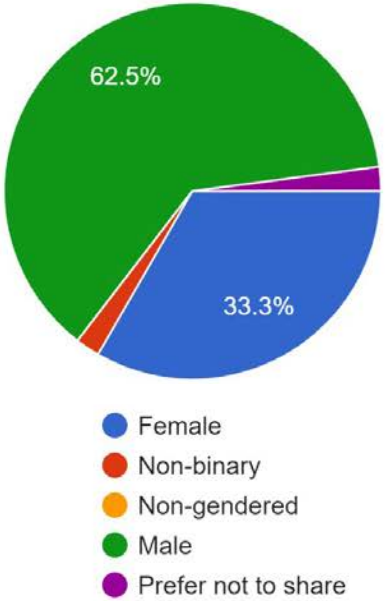
An entry point into Aero/Astro engineering

AA100: Introduction to Aeronautics and Astronautics

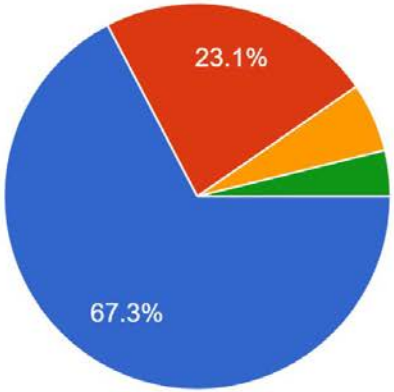
- 3 units
- Offered every Winter
- Undergraduate required Aero/Astro depth course
- Mix of mostly **freshman** (often finding degree path) and **sophomores**
- **Applied physics**, **hands-on** activities, and **real world** examples**.**

Illustrates principles of fluid flow, flight, and propulsion, lift and drag, aerodynamic performance, orbits, maneuvers, space environment, and propulsion for spacecraft, history and challenges of aeronautics and astronautics

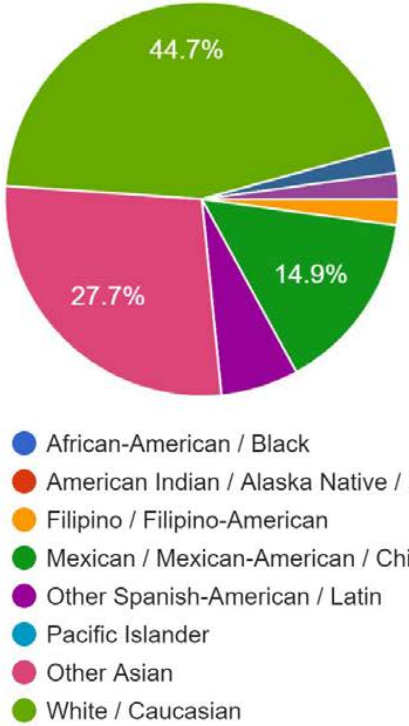
AA100 at a glance



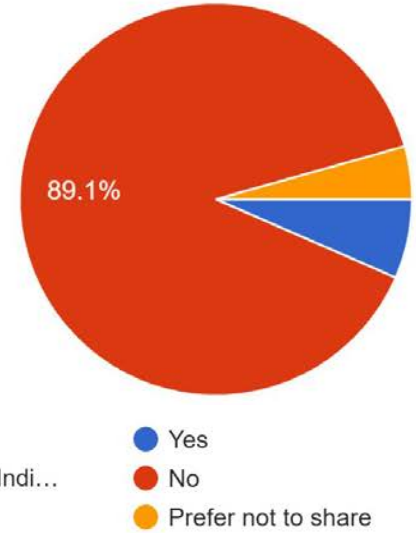
Gender identify



Academic year



Racial identity



Disability identify

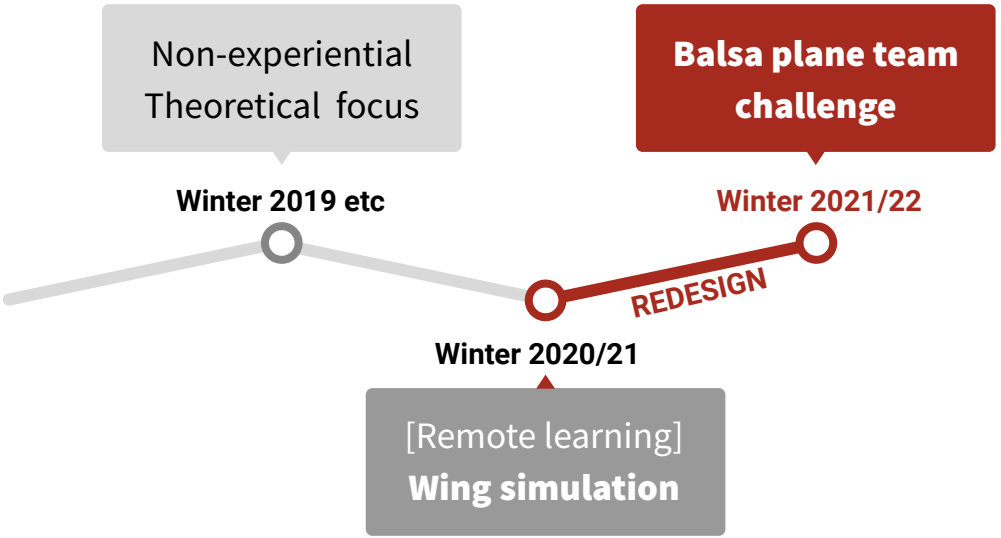
How to engage students in learning?

And make opportunities to apply learning & be creative?

...and maybe even some fun too!

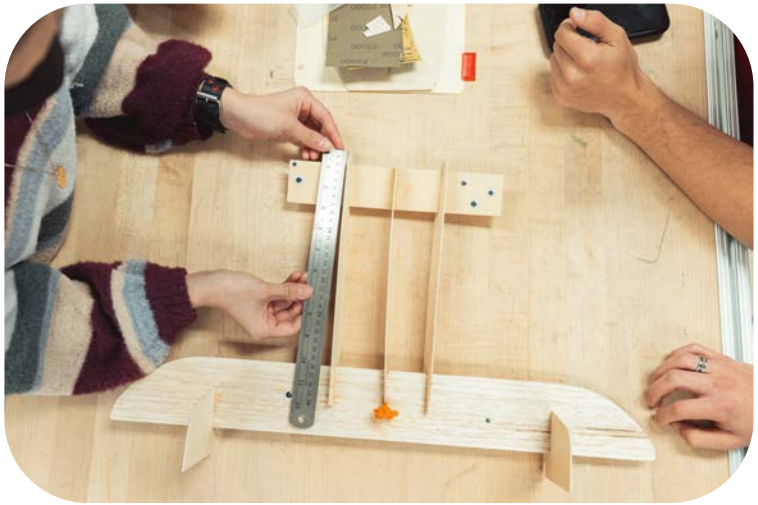
Exploring ways to add experiential learning

Collaborating to design and implement practical activities



Experiential learning: Making a (balsa wood) plane

- **Applying** calculations and theory to create something new
- Rapid **design iterations**
- Testing with practical **experiments**
- **Teamwork** and connection
- Developing **confidence**
- Technical writing



Trying (and failing!) as a team

Forming **communities of practice**

"People who engage in a process of collective learning in a shared domain of endeavor"

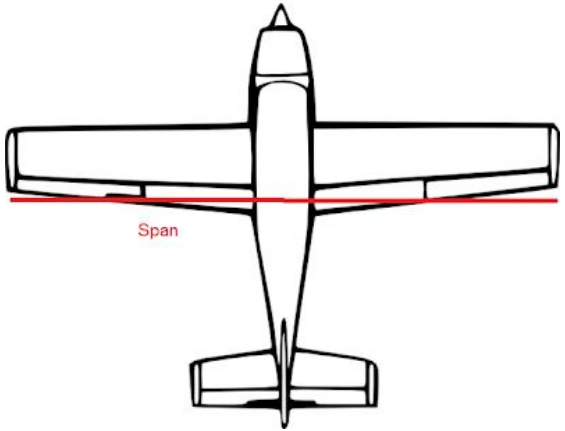
Lave, J., & Wenger, E. (1991). Situated learning: Legitimate peripheral participation. Cambridge university press.

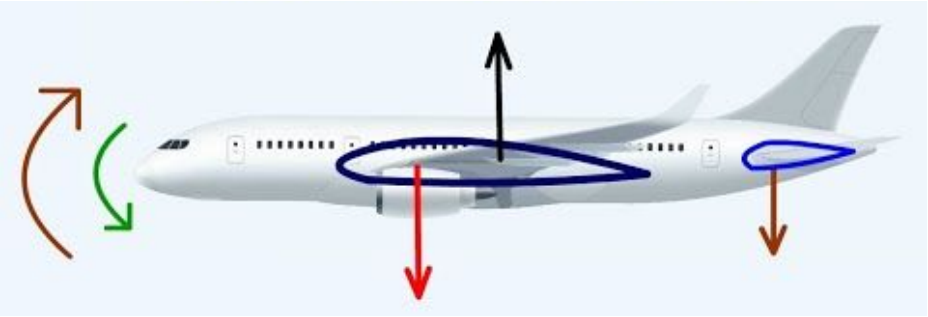
Learning by doing

- Teams of **4-5 students** (self-assigned)
- **Issued same materials**
  balsa wood weights, knife, ruler, glue, plasticine
- Safety materials (cutting mat) & online safety training course (hand tools, sharps)
- Step by step instructions
- **Grading matrix**
- Technical report **templates** with prompts

What theories did students need to know?

- **Aerodynamics**: lift and drag
- **Wing theory**: aspect ratio, angle of attack
- **Flight**: maximum range, lift-to-drag ratio, gliding angle
- **Stability**: center of gravity, pitching moment





https://sites.google.com/site/aerodynamicpropulsion/wings-measurements/wing-calculation

https://www.youtube.com/watch?v=uReN2Nd1yuo

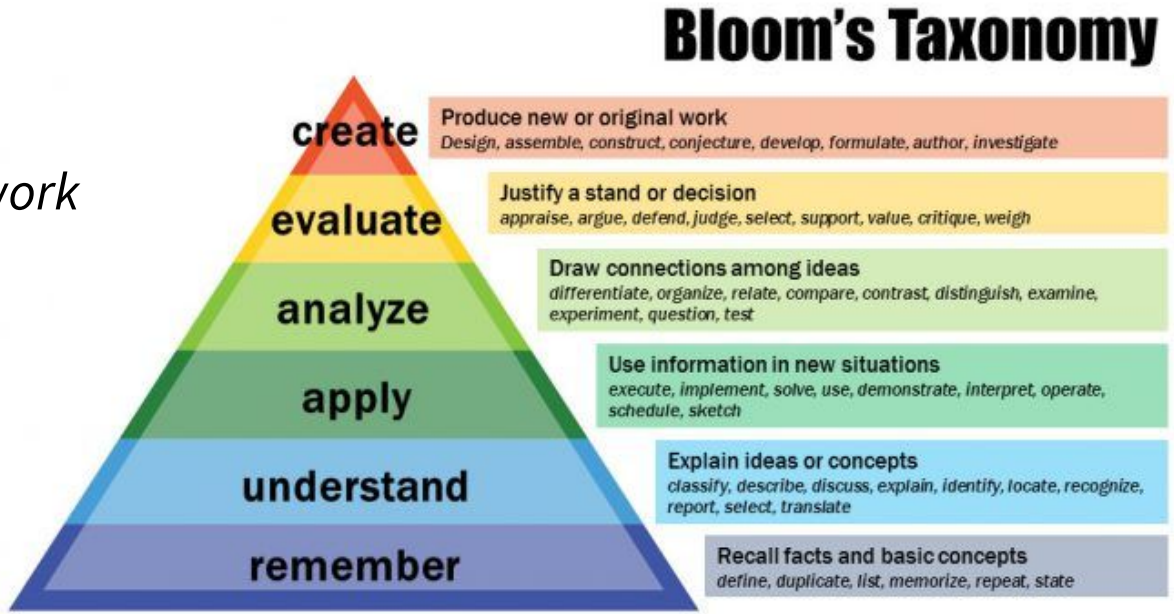
Logistics

- November 2021: Hara and Travaglini initiated the hands-on project idea
- December 2021 (during winter vacation): Hara did his own balsawood design and build. AA departmental approval of the purchase of goods ($700-$1000)
- January 2021: CAs design and test; reordered parts; Travaglini developed design documents and report templates
- February 2021
  - **One course**: introduction to Skilling Lab and initiate group project
  - Open timeslots: students had access to Skilling Lab
  - **One course** (a week later): demonstration of the balsawood aircraft (featured by Stanford News and SOE)
  - A week later: students submit final report

Legitimate engineering and communication skills

Applying Learning
Bloom's Taxonomy
Using *knowledge to* ***create***

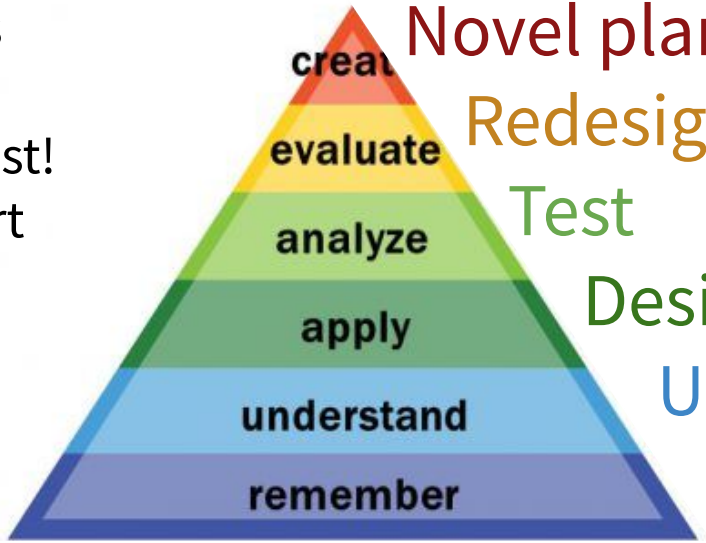
Legitimacy
Preparing for professional work
Emulating *industry*



Krathwohl, D. R. (2002). A revision of Bloom's taxonomy: An overview. Theory into practice, 41(4), 212-218.

Legitimate engineering and communication skills

- ➔ Teams create design proposals
- ➔ Set materials
- ➔ Test plane
- ➔ Final flight test!
- ➔ Written report



Novel plane design

Redesign

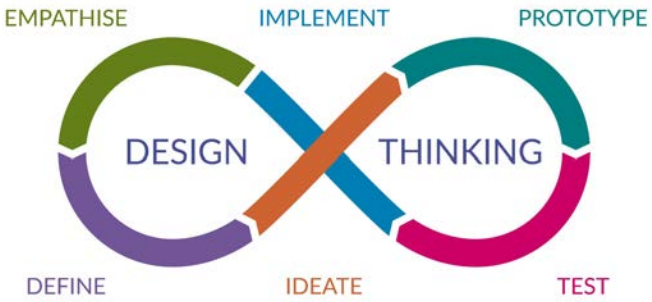
Test

Design prototype plane

Use equations

Know equations

Applying aeronautical skills through a design loop



Johri, A., & Olds, B. M. (2011). Situated engineering learning: Bridging engineering education research and the learning sciences. Journal of Engineering Education, 100(1), 151-185.

Beneficial outcomes

- Positive course feedback
- Community building (especially post remote-learning)
- Encouraging access to engineering identities
- Opportunities for connections outside department

Opportunities for making happy memories!

Where next?

- **Revisit, review, redesign**
  Student feedback, course evaluations, intuitions
- **Tailor to the next class**
  Explore improvements, add teamwork assessment element

Fall 2022

- Review
- Think & talk

Winter 2023

- Redesign
- Lab/faculty recruitment

FLIGHT TEST!

- Community building event

Try it out in your course!

Try out some small adds

Low resolution prototype (mastery grading; completed/not)

Pitch ideas as teams (scaled down to design outline only)

Design iterations (plan, test, redesign)

Explore pedagogy

Redevelop course and/or learning objectives (CTL resources)

Use Bloom's Taxonomy to find practical activities (apply/create)

Contact industry/professional organization and emulate a typical task

Want to know more?

School of Engineering video + more info

THANK YOU!

Experiments in Learning - Experiential Learning for Aeronautical

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