

Flight Physics Concept Inventory

A Multi-Cultural Concept Inventory for Flight Physics

Florian Genz¹, Kathleen Falconer¹, Lars Möhring¹, André Bresges¹

¹ University of Cologne, Germany

► Abstract

The new Flight Physics Concept Inventory (*FlIP-CoIn*) provides feedback to educators and students in introductory physics or aviation science. It elicits common **(mis)conceptions** in fluid dynamics in the context of aviation. FlIP-CoIn was developed in two languages and two cultures. The internal reliability analyses resulted in a **Cronbach $\alpha = .76$** (German) and **$\alpha = .81$** (English version). The bilingual development and item analysis yielded many insights for differences in the use of physics language as well as national teaching cultures.

► Surprising Results

QID027e: Initially, a sailplane (glider) is in steady gliding flight (losing altitude but maintaining relative airspeed). What changes when the center of mass (magically) shifts a little bit forwards and the sailplane, then, reaches a constant speed again?

aerodynamic lift:	<input type="radio"/> is increased	<input type="radio"/> is decreased	<input type="radio"/> stays constant
aerodynamic drag:	<input type="radio"/> is increased	<input type="radio"/> is decreased	<input type="radio"/> stays constant
weight:	<input checked="" type="radio"/> is increased	<input type="radio"/> is decreased	<input checked="" type="radio"/> stays constant
(relative air) speed:	<input type="radio"/> is increased	<input type="radio"/> is decreased	<input type="radio"/> stays constant

Many top-scoring German engineering students ($N_2=155$) answered with „increased“ to the third sub question of question 027e („weight:...“). This was scored wrong and resulted in a negative „corrected item-total correlation“ (CITC) for this sub question. Strictly speaking, they are *correct*, since the sailplane *loses* altitude in the scenario and weight is the force due to gravity. Surprisingly, the English sample of aviation students ($N_1=123$) did have a *positive* CITC. This suggests that the later student group did not distinguish between weight and mass as much as the German group.

Here are some hypotheses for discussion:

- The German engineering assessment culture puts more emphasis on small effects.
- The English aviation teaching culture rewards students who ignore small effects.
- In German the difference between “weight” and “mass” may be more distinct.

► Literature

BROWNELL, J. (2004). Problem-Based Learning in Graduate Management Education: An Integrative Model and Interdisciplinary Application. *Journal of Management Education*, 28(5), 558-577.

BURGIN, S. R., & SADLER, T. D. (2016). Learning nature of science concepts through a research apprenticeship program: A comparative study of three approaches. *Learning Nature of Science Through Research. Journal of Research in Science Teaching*, 53(1), 31-59.

EPA. (2015). U.S. Greenhouse Gas Inventory Report: 1990-2013.

LINDELL, R., DING, L., ENGELHARDT, P. V., CHURUKIAN, A. D., & REBELLO, N. S. (2013). Establishing reliability and validity: An ongoing process. In *AIP Conference Proceedings* (Vol. 1513, pp. 27-29). AIP.

LINDELL, R. S., PEAK, E., & FOSTER, T. M. (2007). Are They All Created Equal? A Comparison of Different Concept Inventory Development Methodologies (Vol. 883, pp. 14-17). AIP.

MISAKO, K., & YOSHIDA, J. (2014). Connecting the Dots: Links between Kinetic Theory and Bernoulli's Principle (pp. 257-260). American Association of Physics Teachers.

NELSON, M. A., GEIST, M. R., MILLER, R. L., STREVELER, R. A., & OLDS, B. M. (2007). How to create a concept inventory: The thermal and transport concept inventory. In *Annual Conference of the American Educational Research Association*, Chicago, IL.

SHEPARD, K. (2008). Higher education for sustainability: seeking effective learning outcomes. *International Journal of Sustainability in Higher Education*, 9(1), 87-98.

VIÉVRA, R., SPRINGER, T., GIPSON, L., WERRIES, M., & SCHULTZ, J. (2015). *Aerodynamics for Introductory Physics*. NASA. Retrieved from https://www.nasa.gov/sites/default/files/atoms/files/Introductory_Physics.pdf

WEBB, K. C., & TAYLOR, C. (2014). Developing a pre- and post-course concept inventory to gauge operating systems learning (pp. 103-108). ACM Press.

WHITMORE, E. K., GRAM, D., MOSEB, B., LINDELL, R. S., & YESENIA, J. (2015). A Kinesthetic Circulatory System Model for Teaching Fluid Dynamics (pp. 359-362). American Association of Physics Teachers.

WELTNER, K., & INGELMAN-SUNDBERG, M. (2003). Physics of flight-reviewed. *European Journal of Physics*.

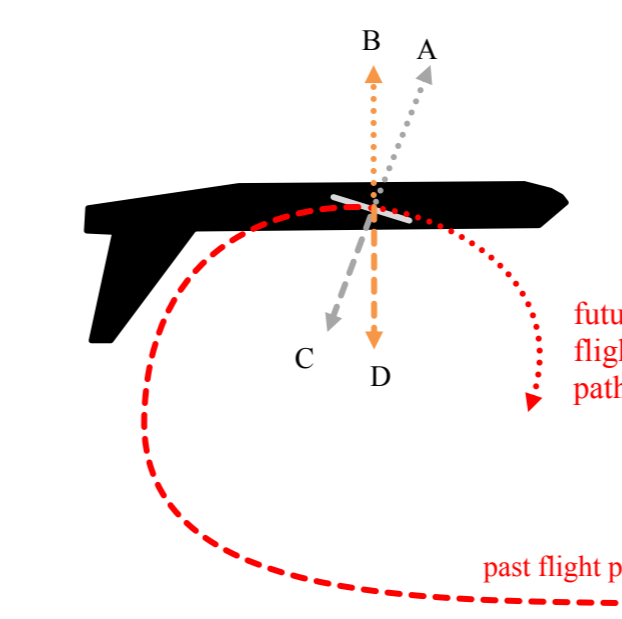
► Motivation

- Climate change is hugely driven by the transportation industry.
- In a world that is ever more dependent on the increasing efficiency of transporting goods, it is imperative to **develop...**

► Concept or misconception?

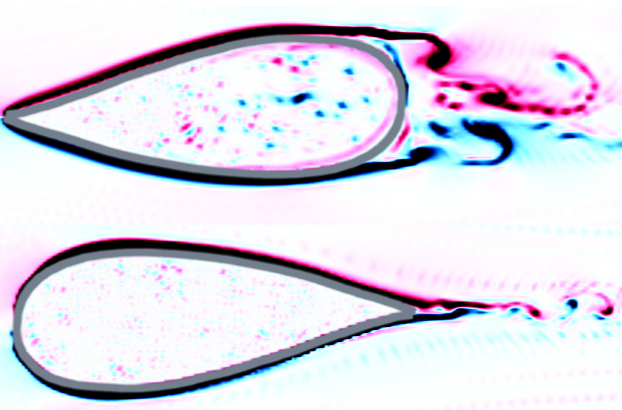
“Aerodynamic lift points upwards!”

This is only true for horizontal flight. In this picture it even points downwards. Our data shows that many students cannot apply this definition, even though they can recite the correct definition of lift”



“Aerodynamic objects are pointy in the front!”

The opposite is true! First and foremost, you want to avoid turbulence in the back.



“Increasing thrust, increases speed!”

For most general aviation planes (like Cessna) increasing thrust means increasing altitude!



...a **solid intuition** for aerodynamics.

- **Misconceptions** in fluid dynamics are still widespread in society and have **great impact** on engineering design of everyday items (cars, rooftop boxes, helmets, boats...).

► Translation Issues

QID0036: When a plane flies a wide turn, what has the greatest influence on the apparent force that pushes the pilot into the seat?

- altitude (How high the plane flies)
- banking angle (How much the plane leans into the curve)
- true air speed (How fast the plane flies)
- thrust (The push of the engine)

Q36	English vers.	German vers.
A)	5%	1%
B)	74%	60%
C)	12%	23%
D)	9%	16%
	n=138	n=105

Banking angle: NASCAR racing is not known in Germany and the word for “banking” is not a widely known one. This gives reason to speculate why German students performed poorer at Q36 even though the German distractor used 3 synonyms. This also contradicts the widely known guessing rule “pick the longest”.

► Summary & Outlook

The Flight Physics Concept Inventory in its current state turns out to be a reliable and validated tool for analyzing one’s own learning intervention in the context of flight physics. Surprisingly, it also turned out as a magnifier for differences in learning or testing culture. The validation process also showed that misconceptions are still widespread among German and English engineering and aviation students. Even flight instructors score below 72%.

Outlook: In the future we will implement an automated scoring and

test result tool for educators to analyze their PRE and POST tests. Another milestone to be reached is setting up a database where educators can upload anonymized test results and compare them with others to facilitate discourse and improve research-based teaching.

Next steps:

- Finding educators to field test with **big N** and **♀** population.
- Translating and revalidating FlIP-CoIn in more (sub) cultures.
- An automated feedback tool for educators.
- Online database for comparing results and further research.

