# electronic Flight Physics Concept Inventory

## eFliP-CoIn$^2$: Concept Inventory Development in two Language Cultures

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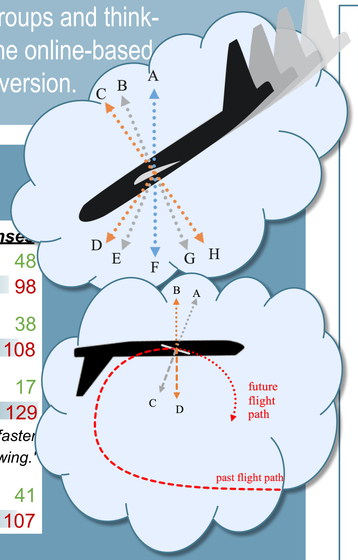
## ▶ Abstract

The Flight Physics Concept Inventory (*FliP-CoIn*) provides feedback to high school and college students in introductory physics as well as their educators about common **(mis)concepts** in fluid dynamics in the context of aviation. Currently, FliP-CoIn is in development in two languages (German and English). With this poster the authors wish to facilitate **collaborative discourse** with concept inventory designers as well as language experts. Due to more focus groups and think-aloud interviews, many improvements were implemented. The online-based implementation was recently tested in the English language version.

## ▶ Surprising Descriptive Results

| QID | Question (shortened) | Frequency of response | |
|---|---|---|---|
| 018 | In the following sketch, which arrow indicates best the direction of aerodynamic lift? | correct | 48 |
| | | incorrect | 98 |
| 017 | In the following sketch, aerodynamic lift is pointing in the direction of... | correct | 38 |
| | | incorrect | 108 |
| 016 | Cause of lift: Aerodynamic lift is generated, due to… | correct | 17 |
| | | incorrect* | 129 |
| 014_I | In horizontal flight, aerodynamic lift is pointing perpendicular to the direction of drag. | marked | 41 |
| | | blank | 107 |

*most frequent answer (n=63): "*the air flowing over the wing is accelerated faster than the air flowing under the wing.*"




**What happens when a general aviation plane (e.g. Cessna) increases its thrust?** QID032

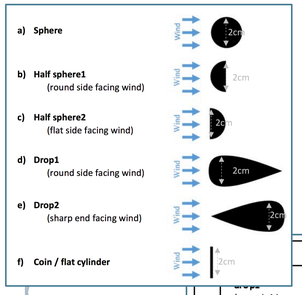
| Flight hours | Answer | Freq. of resp. |
|---|---|---|
| 0 | altitude increases | 4 |
| | speed increases | 24 |
| >0 | altitude increases | 36 |
| | speed increases | 59 |
| >20 | altitude increases | 26 |
| | speed increases | 28 |
| >1000 | altitude increases | 10 |
| | speed increases | 31 |
| | **n=** | **218** |

From the N=1135 aviation students and 21 flight instructors n=270 replied; $n_2$=130 filled the 30min survey complete. Many of the 70 inventory questions revealed interesting results: Especially applying the, mostly known, definition of lift and drag to given situations seems to be a problem – even for advanced students. Further, cause and effect are often not clearly distinguished and result in wrong or inconsistent answer patterns. Moreover, aviation students with 0.7 to 999 flight hours seem to behave different than students with 0 or 1000+ flight hours when predicting flight behavior.

## ▶ Challenges Partially Solved

- Finding **big test populations** for validation of the instrument
- Reconciling the different models of lift (items' independence)!
- Positioning of frustrating drop-out questions
- Curricular challenges (war history of Germany, US science standards)
- Pictures provoking misconceptions
- **…?**

## ▶ Example of Important Change:




**Early version of QID001:**
*„Order the objects by aerodynamic drag (1=lowest drag)"*

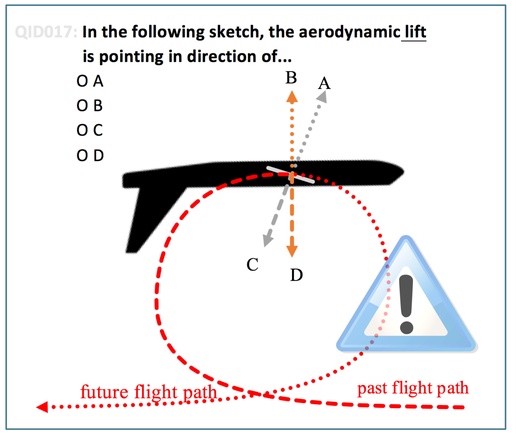
In early versions this question had a high cognitive load, multiple correct answer patterns, and hence was misunderstood often.




## ▶ Pictures can Provoke Misconceptions!

**Problems with iconic representations:** While asking about aerodynamic lift this old picture provokes a misconception in another field: The circle shaped flight path suggests that a plane can maintain its height after a looping.

**Version 20d of QID001:** Looking at piloting data and think-aloud interviews the question was split into 13 binary single-select questions and 3D representations were introduced.




## ▶ Discussion

**Surprising results:** Some of the incorrect answer patterns of aviation students concerning the application of the lift definition seem to be consistent with a "Lift always points up" concept. However, most answer patterns are very inconsistent and even contradicting (see QID14, 17 & 18). This seems to indicate that often there is **no solid concept of aerodynamic lift** yet! Similar can be said for the concepts of drag and thrust – only less drastically pronounced. The question remaining, why students with zero and those with 1000+ flight hours answer similar (see QID032), needs further investigation and might hold interesting results for further improving the inventory.

**Current Challenges:** Finding educational institutes with a big *and* diverse student body to further test *FliP-CoIn,* has proven difficult. The challenge of a concurrent bilingual development of the instrument in English and German turned out to be surprisingly fruitful for eliciting differences in learning culture and linguistic vagueness but it is a constant challenge to iterate items that remain (A) easy to understand, (B) are phrased scientifically correct and (C) are not misleading.

**Next Challenges:**

1. Finding experts in PER and language sciences.
2. Finding educators to field test with big N and ⚥ population.

## ▶ 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.

Misiako, K., & Vesenka, 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*.

Shephard, K. (2008). Higher education for sustainability: seeking affective learning outcomes. International Journal of Sustainability in Higher Education, 9(1), 87–98.

Vieyra, R., Springer, T., Gipson, L., Werries, M., & Schultz, J. (2015). *Aeronautics for Introductory Physics*. NASA. Retrieved from https://www.nasa.gov/sites/default/files/atoms/files/aero_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., Grimm, D., Moser, B., Lindell, R. S., & Vesenka, 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.



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Federal Ministry of Education and Research

„The Future Strategy for Teacher Education" of the University of Cologne is part of the "Quality Campaign for Teacher Education" and sponsored by the German Federal Ministry of Education and Research.

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