Flight Physics Concept Inventory:
Current Challenges and Design for the *FliP-CoIn*

ZUKUNFTSSTRATEGIE LEHRER*INNENBILDUNG

COMPETENCE LABS

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▶ Abstract

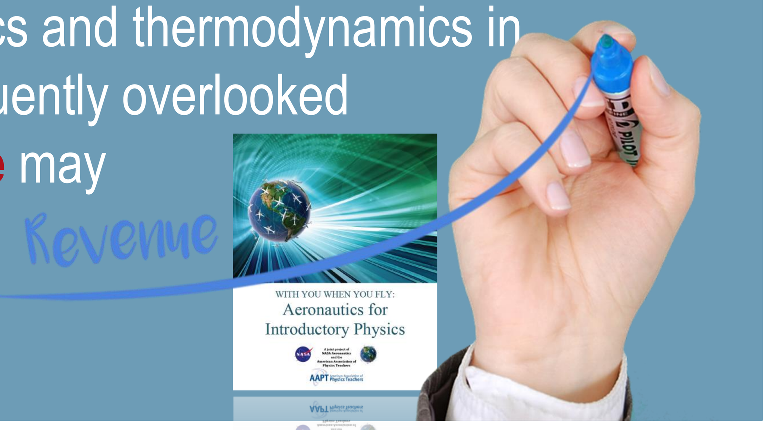
The Flight Physics Concept Inventory (*FliP-CoIn*) will provide feedback to high school and college students in introductory physics as well as their educators about common **(mis)conceptions** in fluid dynamics in the context of flight. Since this tool is still in development, the author is thankful for **collaborative discourse** with concept inventory designers as well as PER and fluid dynamics experts. An online-based implementation is currently in development.

▶ Why we design FliP-CoIn?

Most educational resources provide oversimplified or erroneous explanations about aerodynamic lift and drag in fluid dynamics and thus leading to misconceptions. Building on the NASA/AAPT joint project "*Aeronautics for Introductory Physics*" educator guide (VIEYRA et at., 2015), we are designing a concept inventory to elicit misconceptions about physics in the context of flight.

Misconceptions in fluid dynamics are widespread in society and have great impact on the engineering design of everyday items such as cars and aircraft. Consumers' design decisions ultimately impact fuel efficiency and environmental footprints. There exists a wide variety of misconceptions from misunderstandings about aerodynamic shapes to the misapplication of Bernoulli's principle in the context of flight.

Fluid dynamics is an increasingly important topic in a transportation-based growing "global village". Despite the significance for society, fluid dynamics is often relegated to middle school curriculum, if addressed at all, and tends to fall into the gaps between more thoroughly studied disciplines such as kinematics and thermodynamics in high school. For similar reasons, flight physics is frequently overlooked at universities. **Making misconceptions measurable** may result in more attention to the lack of student understanding and instructional time spent on flight physics and fluid dynamics.

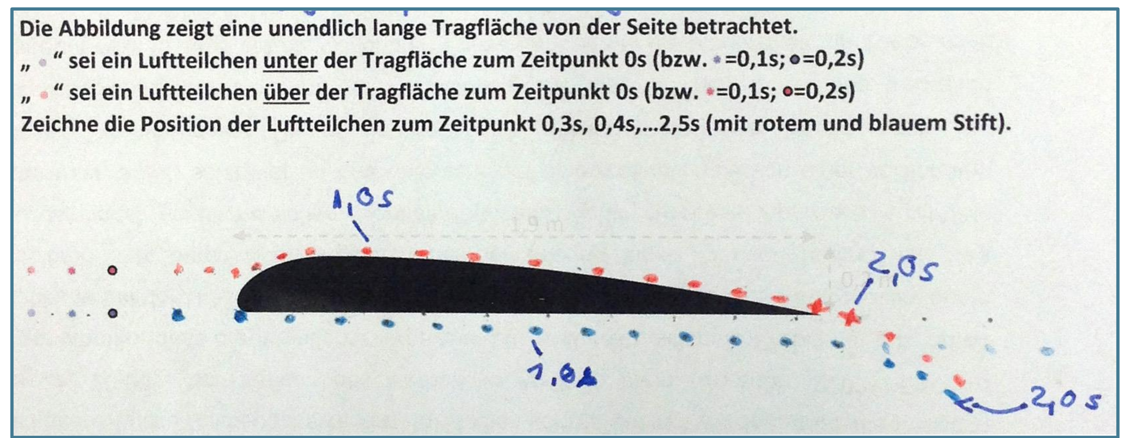


▶ Challenges to Overcome

- Finding **sample of adequate size** for test development
- Lack of research
- Problems caused by online & textbook misinformation
- Problematic iconic representations
- Atypical cases predominate (wind, shear, stall, climb flight)
- Curricular challenges (war history of Germany, US science standards)
- Reconciling the different models of lift (items' independence)!
- **...?**

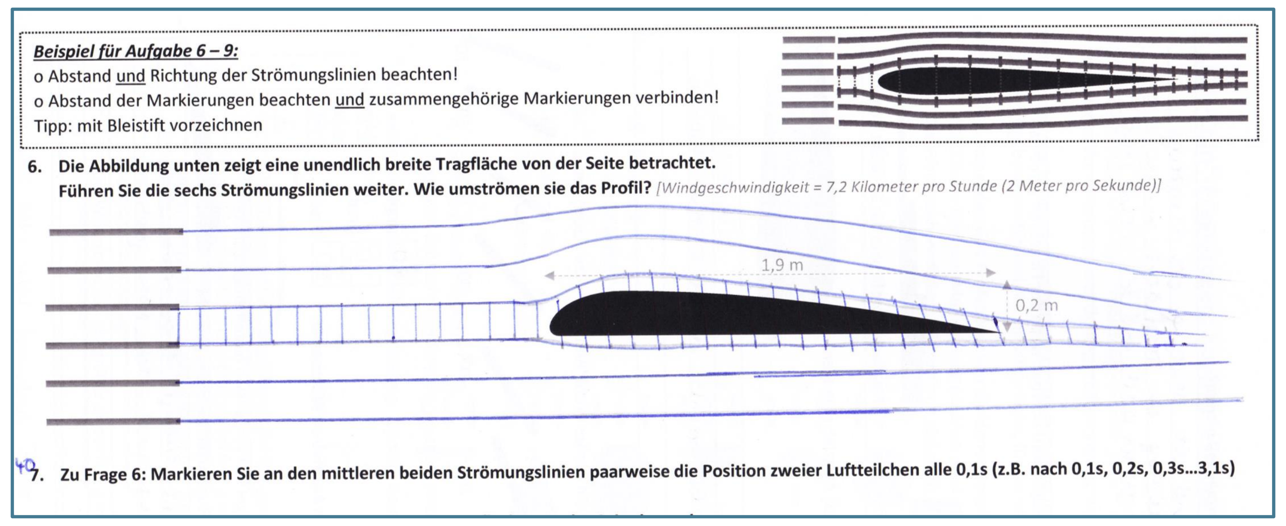
What did we miss?!

▶ Example: The Evolution of Question ID006

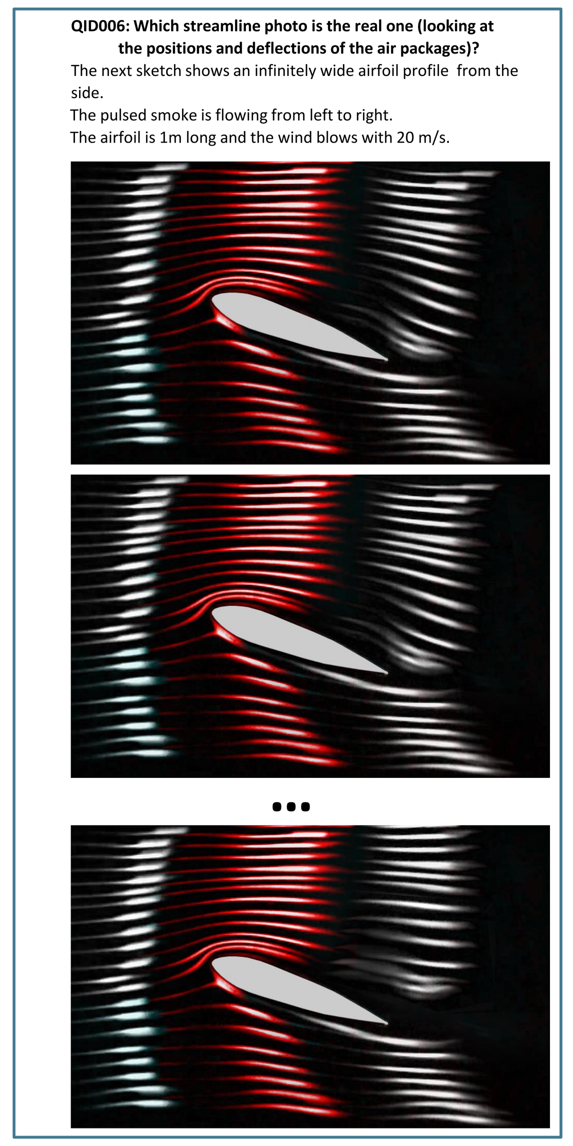


Early version of QID006:
„Draw the position of the air particles for time =0.3s, 0.4s,…2.5s (with a red and blue pen)."
Physics education students piloting the FliP-CoIn had problems understanding this new and semi-open question format. Some could explain the model but were unable to answer the question correctly.

Current version: Since idealized representations caused problems (ie. with identification of symbols, independence to lift theories, unusual question format), we decided to manipulate real photos and test for the two most commonly misunderstood concepts (deflection and speed change) via a closed, forced select and multiple choice question.



Version 7 of QID006: The two aspects of the question (deflection and speed change) were split into two separate questions to reduce cognitive load, example boxes were introduced and streamlines instead of air particles were used to represent the phenomena of interest.



▶ Discussion

Past Procedures: In order to maximize the Inventory's validity, early versions of the *FliP-CoIn* were open ended and based on student answers as well as instructor experience which were collected during the last 4 semesters of our advanced physics laboratory courses. Then, informal expert opinions were collected to precise but also expand the scope of important flight physics problems. Parallel to that, the items went through several iterative design circles based on students' written answer strategies, written comments and "think aloud" video interviews concerning the latest *FliP-CoIn* version. Piloting participants in the iterative development were mostly German science education students.

Current Challenges: The challenges of a concurrent bilingual development of the instrument in English and German were underestimated but also turned out to be surprisingly fruitful for eliciting differences in writing and learning culture and linguistic vagueness. Moreover, it is a constant challenge to crate and iterate items that are (A) easy to understand, (B) phrased scientifically correct and (C) not misleading.

Next Challenges:
1. Finding experts in PER, fluid dynamics and language sciences.
2. Finding educators to field test with big N for an item analysis.
3. Finding test takers fluent in English, German and physics thinking.

▶ Literature

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