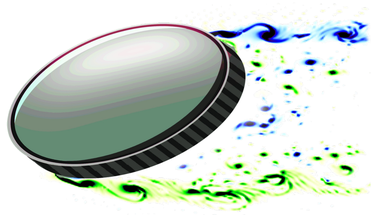

(Naïve) Aerodynamic Concepts in class & in-game:

The Flight Physics Concept Inventory (FliP-CoIn)

ZUKUNFTSSTRATEGIE LEHRER*INNENBILDUNG

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▶ Introduction

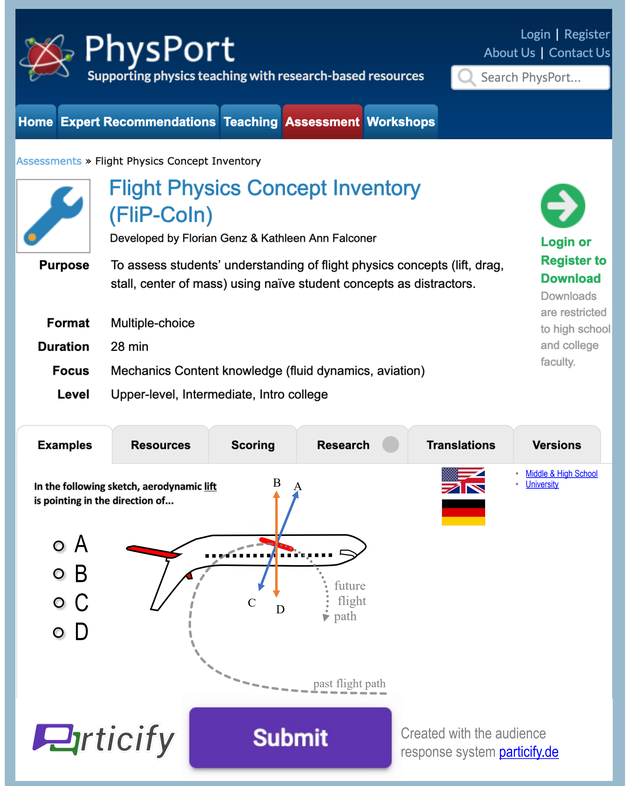
Naïve concepts are particularly hard to elicit in the physics of flight, due to their complexity and overlap. The "Flight Physics Concept Inventory" (FliP-CoIn) is a new automatically scored multiple-choice test for the context of fluid dynamics. It was developed for both online and paper–pencil use as well as for pre- and/or post-evaluation. In gamified form, it serves as a formative assessment and collaborative team building event.

The distractor answers were based on naïve student concepts; The instrument validity and reliability was tested at three big tertiary institutions in the U.S. and Germany specialized for fluid dynamics and aerodynamics.

FliP-CoIn was developed as a multiple-choice single-response instrument with automated scoring. In the online version teachers get instant access to class comparisons via the "PhysPort.org data explorer." A scoring sheet with a coding mask streamlines the visualization of results.

▶ How to get the instrument?

For individual support of the English and German instrument email us via: flip-coin@uni-koeln.de
The Flight Physics Concept Inventory now is also available on PhysPort.org for direct download or online implementation:



Demo quizzes:
For online implementation we prepared ready-to-use example quizzes for aerodynamic lift, drag and angle of attack with the audience response system "Particify": partici.fi/56763245

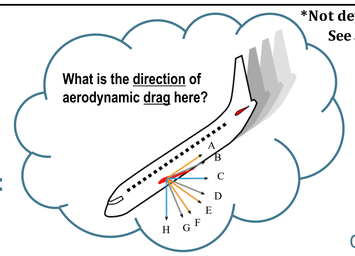
SCAN ME

▶ Concepts covered & prevalence

Concepts assessed by the FliP-CoIn (excerpt)

Concept domain	sub domain		Phrase summarizing the concept	Answer	Prevalence of concept AV
Aerodynamic Lift	Direction:	Naïve:	up / away from earth center	15b	16%
		Naïve:	perpendicular to the wing's upper surface	16a	19%
				15c	42%
				*16b	33%
		Naïve:	up / perpendicular to the wing surface currently upwards	15a	15%
				*16b	33%
		Naïve:	in direction of travel	16e	4%
		Expert:	the lift force points perpendicular to the direction of flight.	*15d	27%
				*16c	26%
	Cause:	Naïve:	air under the wing is accelerated horizontally (nozzle theory)	2b	24%
		Naïve:	air over the wing has a longer path length	*2c	10%
		Naïve:	air has the same horizontal speed over and under the wing	*2c	see above
		Expert:	air over the wing is accelerated	2a	66%
		Expert:	air is displaced along and around the wings	12a	58%
Aerodynamic Drag	Direction:	Naïve:	to the tail end of the airplane	*1a	59%
		Expert:	drag force points against the direction of flight	*1a	59%
		Expert:	drag force points in the direction of the undisturbed flow	*1a	59%
		Naïve:	to the tail end of the airfoil	1b	15%
		Naïve:	always horizontal	1c	14%
		Naïve:	a mixture of concepts (uncertain or compromise)	1d	1%
				1e	2%
		Naïve:	down from the airplane bottom side	1f	4%
		Naïve:	down from the airfoil bottom side	1g	2%
		Naïve:	always down	1h	3%
	Factors	...			
Stall		...			

*Not detectable by only one question.
See also other *-marked answers



Further concept domains assessed:
- Center of mass,
- Angle of attack,
- Flight experience discriminating questions,
- Streamlines & airfoil profiles.

Every question covers at least one concept domain aspect ("phenomenological primitives" (diSessa, 1988))

Which flight physics concepts do YOU find hard to teach?
Leave a feedback if you like:

▶ Implementation in a gamified lecture

The core idea is an online or offline quiz, with team scores presented after each question. In this manner student teams will know whether they have an expert concept there or need to pay more attention to this part during the lecture. We even recommend splitting up the lecture and interweaving the questions to create many phase changes and isles of active learning.

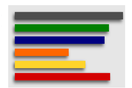
a) **Framing**: Emphasize that the focus of the quiz is not on how much they get correct but why.

b) **Motivation** can be raised by a fun prize or extra credit.

c) **Team building**: We prefer heterogeneous or randomized groups of 3-4 students.

d) **Team identification:** let groups find a creative team name.

e) **Interim scores:** For best learning gains, we present team scores after each question and give time to let students talk to other groups before moving on. Groups who picked a wrong answer will now be eager to know exactly what they misunderstood. Groups who were correct will feel empowered to explain their concept behind the correct answer.



f) **Contrast misconceptions 1st:** After each question, we explicitly name the underlying misconcepts and give vivid examples where they fail.

g) **Expert concepts 2nd:** We let student groups present them. Encourage visual examples, metaphors and/or story-telling while referring back to the differences between naïve and expert explanations. These techniques have been proven to be of great value in terms of overcoming sticky misconceptions (Muller, 2008, 2012).

Here you find a presentation and video for a gamified lesson including explanations after some questions:

is.gd/Z0RHf6

▶ Literature & Links

Flight Physics Concept Inventory (FliP-CoIn) Project Page: https://www.researchgate.net/project/Flight-Physics-Concept-Inventory-FliP-CoIn & flip-coin.uni-koeln.de
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