Hands-on & Minds-on Particle Physics in S'Cool LAB at CER

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S'Cool

S'Cool LAB – a new Physics Education Research facility at CERN

S'Cool LAB is a new Physics Education Research facility at CERN, the world's largest particle physics laboratory in Geneva, Switzerland. High-school students and their teachers contribute to research projects by taking part in hands-on & minds-on particle physics experiments on-site at CERN.



Origin of Students in S'Cool LAB



characteristics, students' preexisting conceptions of particle physics

Methods: pre/post questionnaires, interviews, multiple regression analysis, multilevel modelling

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- Very high demand from all around the world
- In 2017, 5858 students participated in S'Cool LAB programmes:
 - 1030 in S'Cool LAB Days (full-day research programme)
 - 4828 in Cloud Chamber Workshops (90 min workshop)
 - 24 in the S'Cool LAB Summer CAMP (2 weeks)

Learning Activities in S'Cool LAB

Learning activities in S'Cool LAB are based on known students' conceptions and include predict-observe-explain tasks (White & Gunstone, 1992) to foster conceptual change. They focus on affective & cognitive effects through learning with "hands, head, & heart" (Pestalozzi, 1826).



Hands-on experiments in the fields of particle detection, acceleration and medical applications to make CERN's physics understandable



Affective & Cognitive Effects of S'Cool LAB

For the main study, students filled in questionnaires before and after their visit to CERN to assess their interest and self-concept in physics as well as the situational interest and selfconcept in S'Cool LAB. In addition, relevant student and lab characteristics derived from Falk & Dierking's Contextual Model of Learning such as age, gender, prior experiences and grades, perceived cognitive load, tutor support, novelty, etc. were measured. gender: 33% female, 67% male | average age: 17.0 years





Minds-on experimental tasks structured in predict-observe-explain cycles to keep students cognitively active



Hearts-on interactions through challenging group work and diverse CERN volunteers including Q&A with potential role models





Do S'Cool LAB workshops foster students' conceptual understanding? Dependent t-test, N=454, α=0.05, ** p<0.01, 6 items

Conceptual understanding pre / post



predictive student & lab characteristics β interest physics 0.19*** self-concept physics 0.01 0.24 *** curiosity state particles 0.20*** novelty (inverse) 0.31 *** tutor support Experiences with hands-on experiments¹ -0.07* adjusted R^2 48% standard error of estimate (SEE), % of mean 17% ¹ excluded from model: age, gender, cognitive load, curiosity trait, grades ma, en, ph, experience osleos, particle phys. exp. Which student and laboratory characteristics predict the cognitive outcomes of S'Cool LAB? Hierarchical Multiple Lin. Regression, N=454, ***p<0.001, *p<0.1 predictive student & lab characteristics

P _s
0.39***
0.09
-0.06
0.03
-0.15***
-0.06
0.06
0.08
0.14**
0.11*
0.09*
34%
42%

Falk and Dierking's Contextual Model of Learning

A theoretical framework to describe, explain or predict learning in informal learning settings



visit motivation & expectations, prior knowledge and experiences, learning mode, interests, attitude, values, beliefs

> cultural factors and background, social interaction factors: within group, between staff and students, ...

Summary and Future Work

Participation in S'Cool LAB workshops leads to medium-sized cognitive and affective effects on high-school students, despite the relatively short intervention time. To maximise the effects of a visit to a hands-on learning lab like S'Cool LAB:

students (and their teachers) should

- be interested & curious about particle physics
- understand and speak English well enough come well prepared (organisation of the trip, information about the way of working and the underlying physics concepts)

labs like S'Cool LAB should

- be well organised
- aim for the right level of cognitive load of the experimental tasks
- find and train fantastic tutors

Future research will focus more on the cognitive effects of S'Cool LAB including a more precise measurement through a higher number of standardized concept test items.

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Literature: Falk, J. H., Dierking, L. D. (2012). The Museum Experience Revisited. Pestalozzi, J. H. (1826). Schwanengesang. In: Ausgewählte Werke. Boldemann, O. & Günther, K. H. Bd 4, 149-344. White, R. T., Gunstone, R. F. (1992). Probing Understanding. *Great Britain: Falmer Press*.