Hands-on Particle Physics Experiments for High-school Students at S'Cool LAB / CERN

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Outline

① S'COOL LAB – A HANDS-ON PARTICLE PHYSICS LAB

② CONCEPT OF S‘COOL LAB WORKSHOPS

③ AFFECTIVE OUTCOMES OF S’COOL LAB
① S'COOL LAB – A HANDS-ON PARTICLE PHYSICS LABORATORY FOR HIGH-SCHOOL STUDENTS
Aims of S’Cool LAB

DISCOVERY
Give insights into the working methods, technologies and research of the world's largest particle physics laboratory

CURIOSITY
Spread CERN's spirit of science curiosity

UNDERSTANDING
Make CERN's physics and technologies understandable to students through hands-on experimentation
S'Cool LAB – conception

HANDS-ON PARTICLE PHYSICS LEARNING LABORATORY

For high-school students and teachers
International audience from more than 20 countries
Independent experimentation in small groups
Support by volunteering CERN scientists
S’Cool LAB days (1000 students p.a.) and
S’Cool LAB “light” (6000 participants p.a.)
S'Cool LAB – conception

200 m² MODULAR LABORATORY SPACE AT CERN

State-of-the-art IT equipment incl. videoconferencing
Experiments for schools linked to CERN’s scientific
programme and technologies, e.g.

- superconductivity
- PET
- cloud chambers
Example: Positron-Emission-Tomography (PET)

**Components of the setup:**

1. Two scintillation counters (detectors)
2. Cassy – Multichannel analyzer (MCA)
3. Power supply ($U = 0.75kV$)
4. Laptop with software Cassylab
5. Radioactive preparation ($^{22}Na$)

**Description:**

$^{22}Na$ converts the emission of a positron into an excited state of $^{22}Ne$.

This emitted positron annihilates with an electron to two photons ($\gamma$). These annihilation photons are converted by the two scintillation counters with integrated photomultiplier into an electrical signal which is proportional to the energy of the incident photons. The various signals are attributed to channels by the Cassy-MCA. This can be evaluated with the software Cassylab.2
S'Cool LAB – conception

TEST BED FOR PHYSICS EDUCATION RESEARCH

Development and evaluation of student activities accompanied by research in physics education
PER in S‘Cool LAB – design & research questions

Area of research 1: Affective outcomes of S‘Cool LAB

- Has S‘Cool LAB the potential to raise students’ curiosity towards particle physics?

Area of research 2: Cognitive outcomes of S‘Cool LAB

- How much does students’ conceptual understanding regarding the conducted experiments improve in the framework of S‘Cool LAB workshops?
② CONCEPT OF S’COOL LAB WORKSHOPS
Students’ conceptions and POE tasks

“Students’ prior knowledge can interfere with how they observe and remember lecture demonstrations” (Miller, Lasry, Chu, & Mazur 2013)

Prediction-Observation-Explanation tasks in S’Cool LAB based on White & Gunstone (1992)
Example: electron gun – particle acceleration

CERN’s Large Hadron Collider
6.5 TeV protons, 27 km circumference

Electron tube in S‘Cool LAB
300 eV electrons, 30 cm length
③ AFFECTIVE OUTCOMES OF S’COOL LAB
Appreciation of S’Cool LAB and the experiments

- pilot phase from May to June 2016:
  - 96 students
  - 35% female / 65% male
  - avg. age 16.8 years (grades 9 – 12)
  - students from Germany, Spain, Sweden, The Netherlands, and Turkey
  - Avg. Math grade 77%, avg. Physics grade 75%
- Students filled out (online) questionnaires before and after their visit

http://cern.ch/e-scoollab
Dependent t-test results

• significant difference between hands-on workshops in S’Cool LAB and guided tour
  - **Enjoyment**
    \[ t(95) = 4.81, p < .001**, Cohen's d' = 0.49 \]
  - **Perceived learning gain**
    \[ t(95) = 3.45, p < .001**, Cohen's d' = 0.39 \]

→ Students enjoy both parts of their full-day programme at CERN and report that they have learned a lot during the day

→ Students like S’Cool LAB more than the tour

Enjoyment & perceived learning gain

- The guided tour at CERN
- Working on the experiments in S’Cool LAB

Error bars indicate ±1 SD
Evaluation S’Cool LAB experiments

Independent t-test results
• No significant difference in perception of experiments by girls and boys
→ Favourite experiment: Cloud Chamber
→ Very promising: PET experiment

Evaluation of the experiments

- Cloud Chamber
  - Female: 94%
  - Male: 89%
  - (♀34 ♂62)
- Electron tube
  - Female: 67%
  - Male: 73%
  - (♀27 ♂51)
- X-rays
  - Female: 76%
  - Male: 81%
  - (♀27 ♂51)
- PET
  - Female: 76%
  - Male: 92%
  - (♀7 ♂11)

Error bars indicate ±1 SD

(♀ female, ♂ male)
Motivation variables physics: Interest / Engagement and Self concept

Dependent t-test results
- significant difference between post and pre results
  - Interest / engagement
    \[ t(95) = 9.71, p < 0.001** \]
    Cohen’s \( d^1 = 0.94 \)
  - Self concept
    \[ t(95) = 8.08, p < 0.001** \]
    Cohen’s \( d^1 = 0.86 \)
  → High situational interest in S’Cool LAB
  → High self-concept in S’Cool LAB

Motivation variables pre / post

1 calculated according to Dunlop, Cortina, Vaslow & Burke (1996, p. 171)
Curiosity state particle physics

Dependent t-test results

• No significant difference between post and pre results

• $t(92) = 0.82, p = 0.414$

→ Curiosity regarding particle physics is already high before the visit to S’Cool LAB

Curiosity state pre / post

- Curiosity state particle physics

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<th>Pre</th>
<th>Post</th>
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<td>71%</td>
<td>73%</td>
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“I had the idea of studying physics from before, but everyone kept telling me that it was crazy and it had pretty few professional exits. Thanks to your experiments I am convinced now that I want to at least try it.”

Student after S’Cool LAB workshop

Thank you for your attention!
Literature


