Students' Conceptions and Hands-on Learning of Particle Physics in S'Cool LAB

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WHY FOCUS ON STUDENTS‘ CONCEPTIONS?

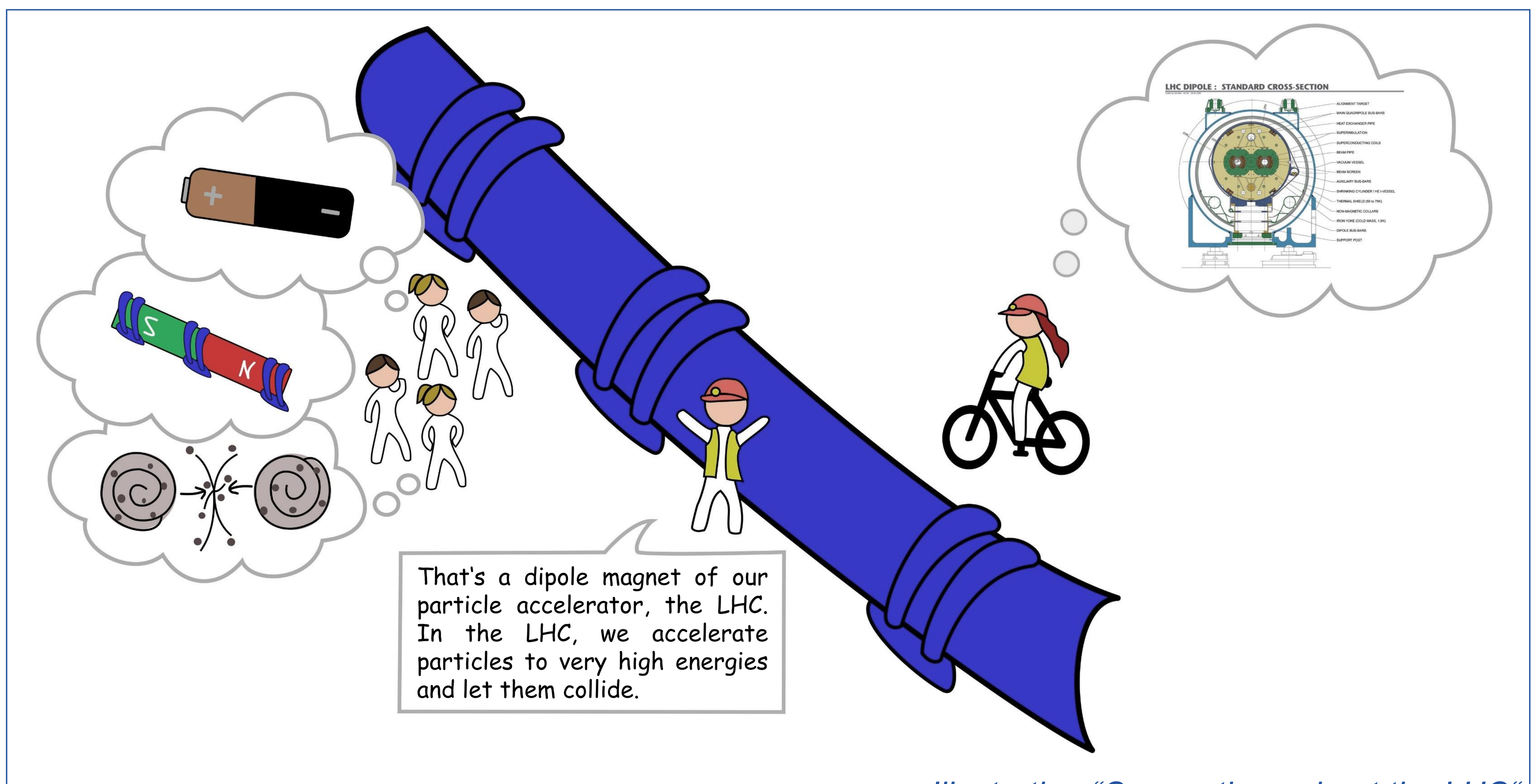
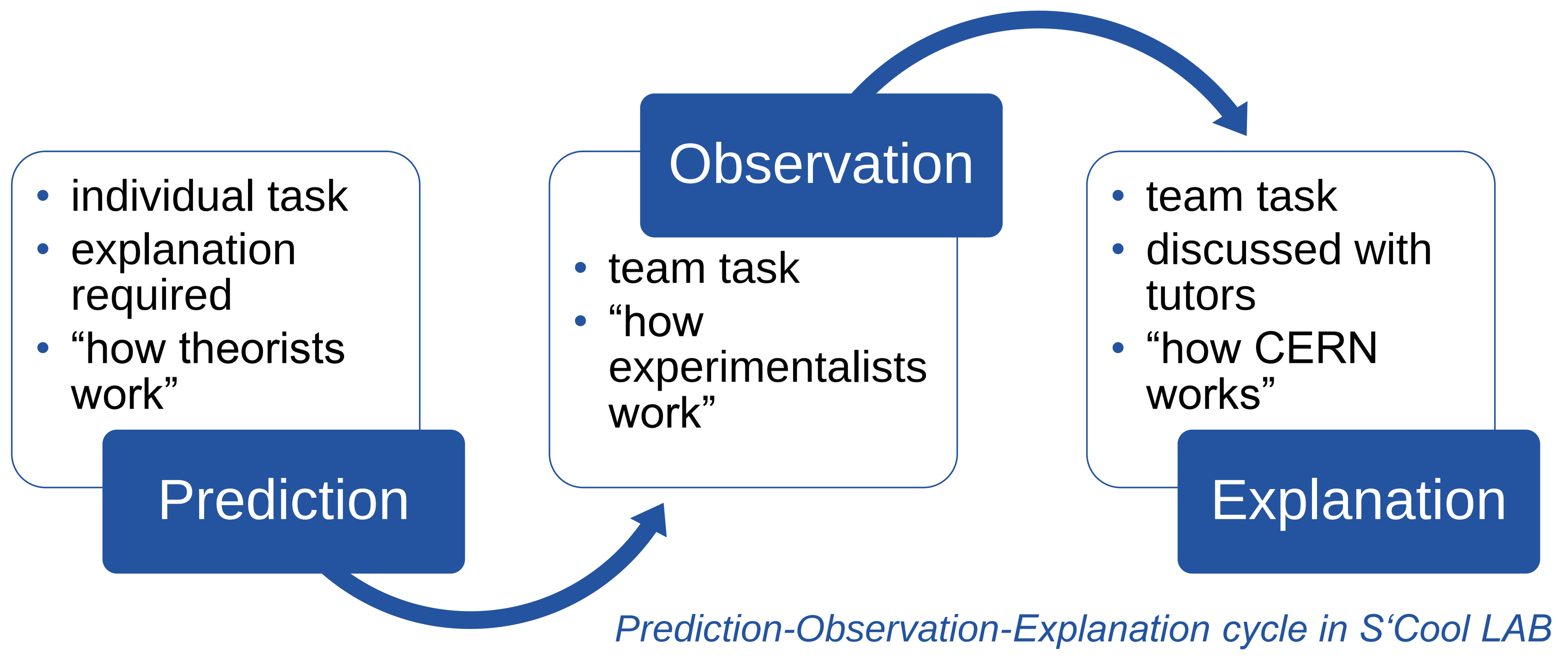


Illustration "Conceptions about the LHC"

"For museum professionals, knowledge of the audience's conceptions of the issue to be presented in an exhibition should always be considered in the exhibition development process, and it should be noted that the audience's conceptions may prevent the intended interpretation of information presented at a museum." (Henriksen & Jorde, 2001)

- Not only museum professionals, but all out-of-school learning places including hands-on learning laboratories like S'Cool LAB need to be ware of their audiences' conceptions.
- If students' conceptions are not addressed, learning might be prevented or instruction might result in fostering misconceptions as illustrated in the cartoon above.
- The use of language plays an important role to lead lay persons to the right conceptions and prevent misinterpretation e.g. of the use of magnets in a particle accelerator as shown in the following quotation: *"Giant magnets accelerate particles of matter close to light speed, and then smash them together." (Fischer, 2009)*

HOW TO FOCUS ON STUDENTS‘ CONCEPTIONS



Prediction-Observation-Explanation cycle in S'Cool LAB

Research questions

- Which conceptions do students have when performing particle physics experiments?
- Is it possible to improve students' conceptual understanding through participation in S'Cool LAB workshops?

Research methods

- Prediction-Observation-Explanation (POE) tasks (explore of students' conceptions)
- Under development: concept test (measure student conceptions)

Prediction-Observation-Explanation (POE) Tasks (White & Gunstone, 1992) based on documented students' conceptions are an integral part of experimental activities in S'Cool LAB with the goal:

- To assess / study students' conceptions (Liew & Treagust, 1998)
- To evaluate and improve the hands-on learning activities in S'Cool LAB
- To foster learning through more correct experiment observations (Miller, Lasry, Chu, & Mazur, 2013)

EXAMPLE FOR PREDICTION-OBSERVATION-EXPLANATION TASK ADDRESSING STUDENTS‘ CONCEPTIONS IN S‘COOL LAB: IONISING RADIATION OF AN X-RAY SOURCE

Equipment:

- X-ray source 35 kVp
  Tungsten anode
  PHYWE
- MX-10 pixel detector
  Timepix chip
  JABLOTRON
- Fluorescent screen
  PHYWE

During this S'Cool LAB workshop, students work independently with X-ray machines and MX-10 pixel detector and learn about the absorption of photons in matter.
Students' conceptions about radiation have been reported by previous studies. The following conceptions are currently addressed in S'Cool LAB workshops:

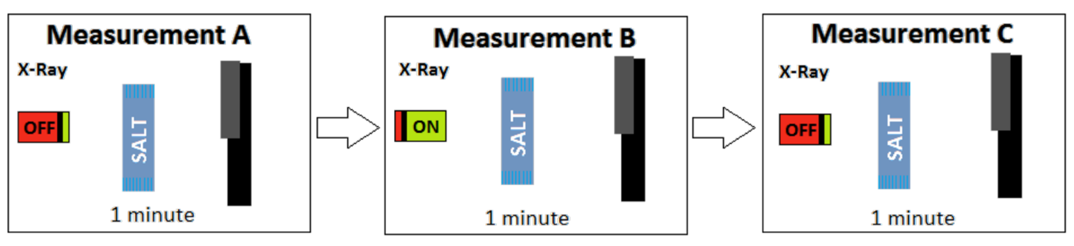
a) *"After irradiation with X-rays, objects become radioactive themselves."* (Eijkelhof, Klaassen, Lijnse, & Scholte, 1990)

b) *"The transparency of material is the same for X-rays as for visible light."* (Clément & Fisseux, 1999)

c) *"Ionising radiation is deflected by a screen like visible light."* (Riesch & Westphal, 1975)

Example for POE task – Irradiation vs. contamination

- Students irradiate salt and measure whether it becomes radioactive using pixel detectors by comparing three consecutive measurements (A, B & C see picture below).
- Before they start the experiment, students predict the outcome.



The detector will measure…	Prediction (N=86)	Example for students' explanations of the prediction	Observation (N=81)
more particles in C than in A	*43%*	*"Salt takes up radiation." "X-rays can make salt unstable." "Radiation from measurement B is still present."*	28%
approximately the same number of particles in C and A	**21%**	*"Salt does not radiate, stores no X-radiation." "Photon is consumed in the same way as for normal light: If light off, no light -> no photons"*	**36%**
fewer particles in C than in A	20%	*"Salt blocks." "Salt absorbs the X-rays."*	22%
the detector will measure no particles in C or A	16%		14%

Results of the POE task

- Only 36% of the students report the correct observation of this experiment.
- 63% of the students' predictions show misconceptions about radiation (students apply matter-like properties instead of process properties to radiation), consistent with findings by Eijkelhof, Klaassen, Lijnse, & Scholte (1990)

Conclusion

- Known students' conceptions about radiation were reproduced with POE tasks and among an international audience in S'Cool LAB.
- Guidance through worksheets and tutors does not guarantee correct observation of the experiments in a hands-on learning laboratory. Because correct observations are important for learning processes, student worksheets need to be further improved.
- Some of the written explanations of correct observations inconsistent with students' initial predictions support the assumption that students learn about physics concepts in S'Cool LAB. A concept test based on findings from POE tasks will be used in the future to measure learning in S'Cool LAB.

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