Using Lesson Study as a research approach in educational design research on special relativity at the secondary level

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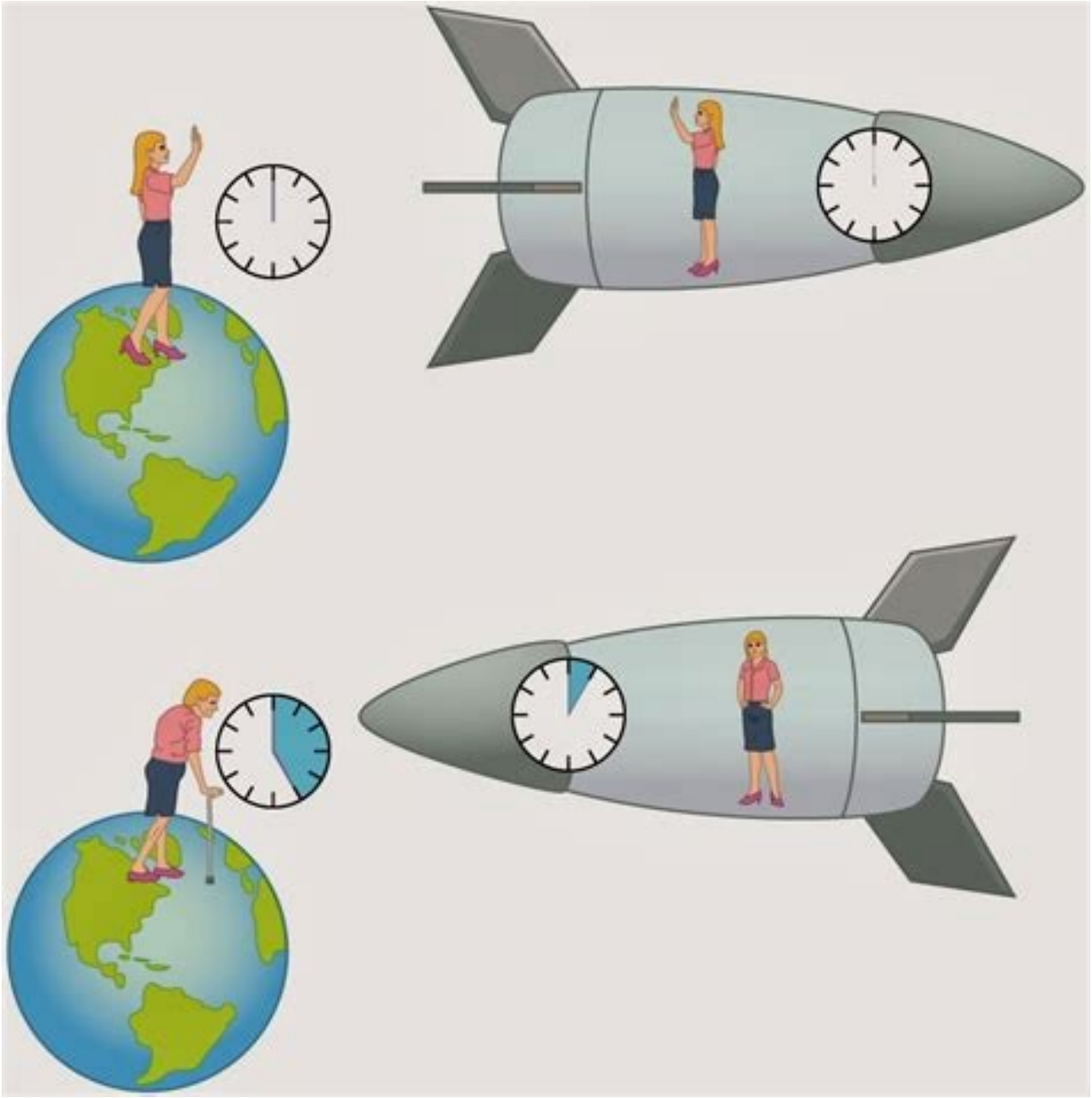
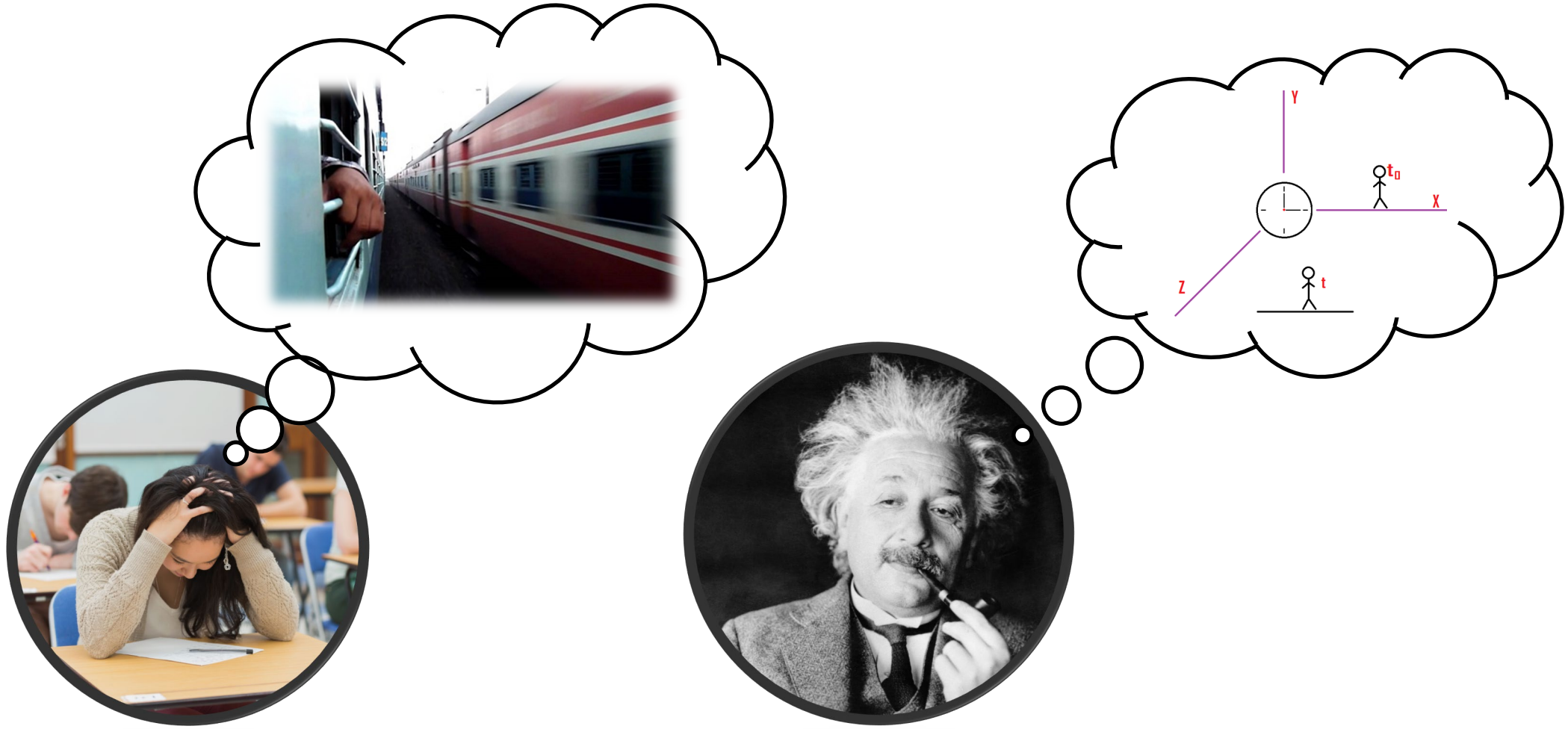
Einstein's Special Relativity Theory (SRT)

According to Einstein, space and time intervals are **relative quantities**.

But only noticeable at relative velocities near the **speed of light** (300.000.000 m/s).



Understanding SRT in secondary education



Relativity Lab: a simulation environment for SRT

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Designing and Evaluating Relativity Lab: A Simulation Environment for Special Relativity Education at the Secondary Level

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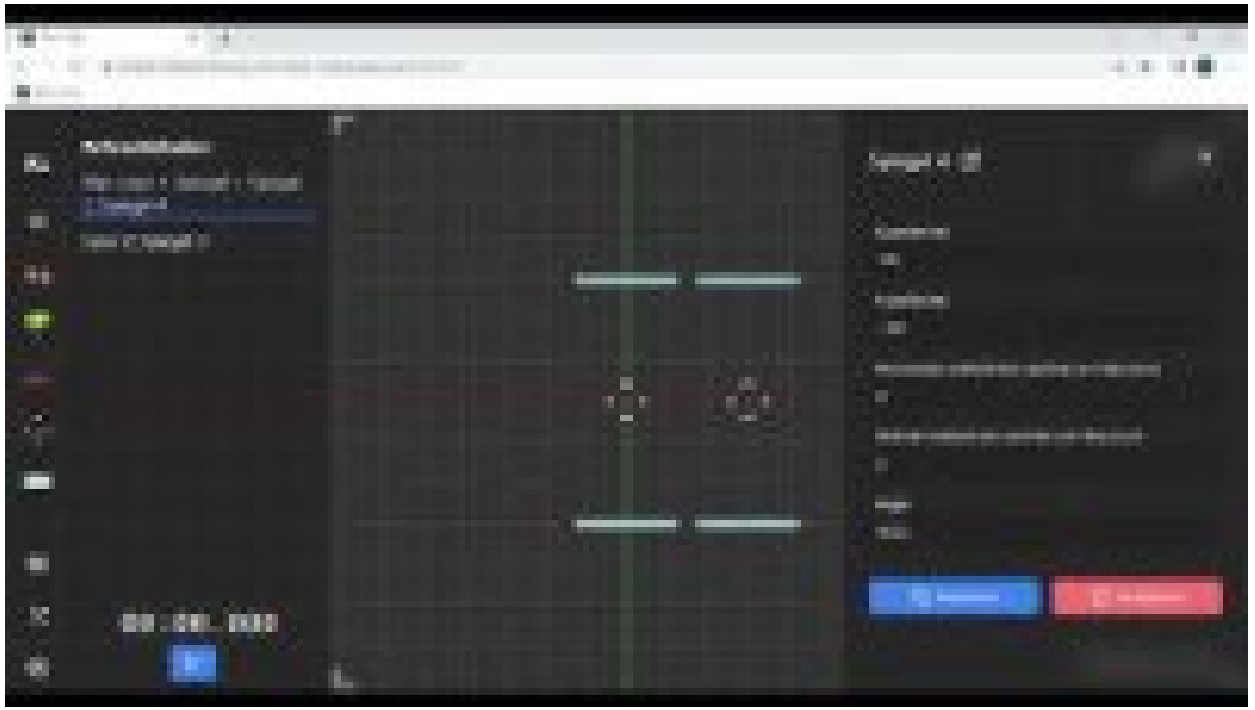
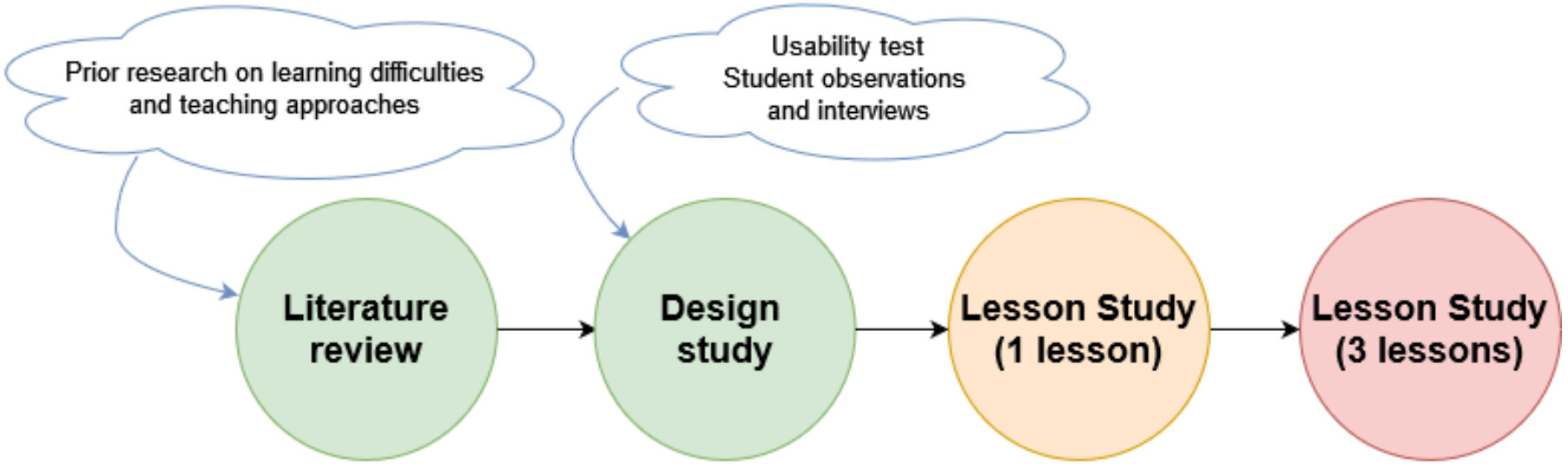
Abstract
This article describes the design and evaluation of a simulation environment for special relativity (SR) education at the secondary level. In recent years, SR has become increasingly popular in secondary school curricula worldwide. Because the key concepts in SR are very remote from everyday experience, they are difficult for students to learn. Computer simulations provide a promising approach to explore these abstract concepts in a simplified and idealized virtual environment. The currently available simulation tools for SR, however, are limited in terms of usability and flexibility. We report on the development of an online simulation environment, named Relativity Lab. In Relativity Lab, students can construct simulations themselves and freely select the inertial frame of reference from which the simulation is rendered. We performed a small-scale evaluation ($N = 16$) in which Relativity Lab was used in inquiry-learning activities. Results indicate that students found Relativity Lab a helpful tool for visualizing relative motion and relativistic light propagation. Moreover, the inquiry-learning activities helped students to recognize discrepancies between their prediction and the outcome of a simulation. We propose improvements to the current task design by providing stricter instructions with regard to constructing the simulation and switching between inertial frames.

Keywords Special relativity · Computer simulations · Secondary education



[1] Alstein, P., Krijtenburg-Lewerissa, K. & van Joolingen, W.R. Designing and Evaluating Relativity Lab: A Simulation Environment for Special Relativity Education at the Secondary Level. *J Sci Educ Technol* (2023). https://doi.org/10.1007/s10956-023-10059-8

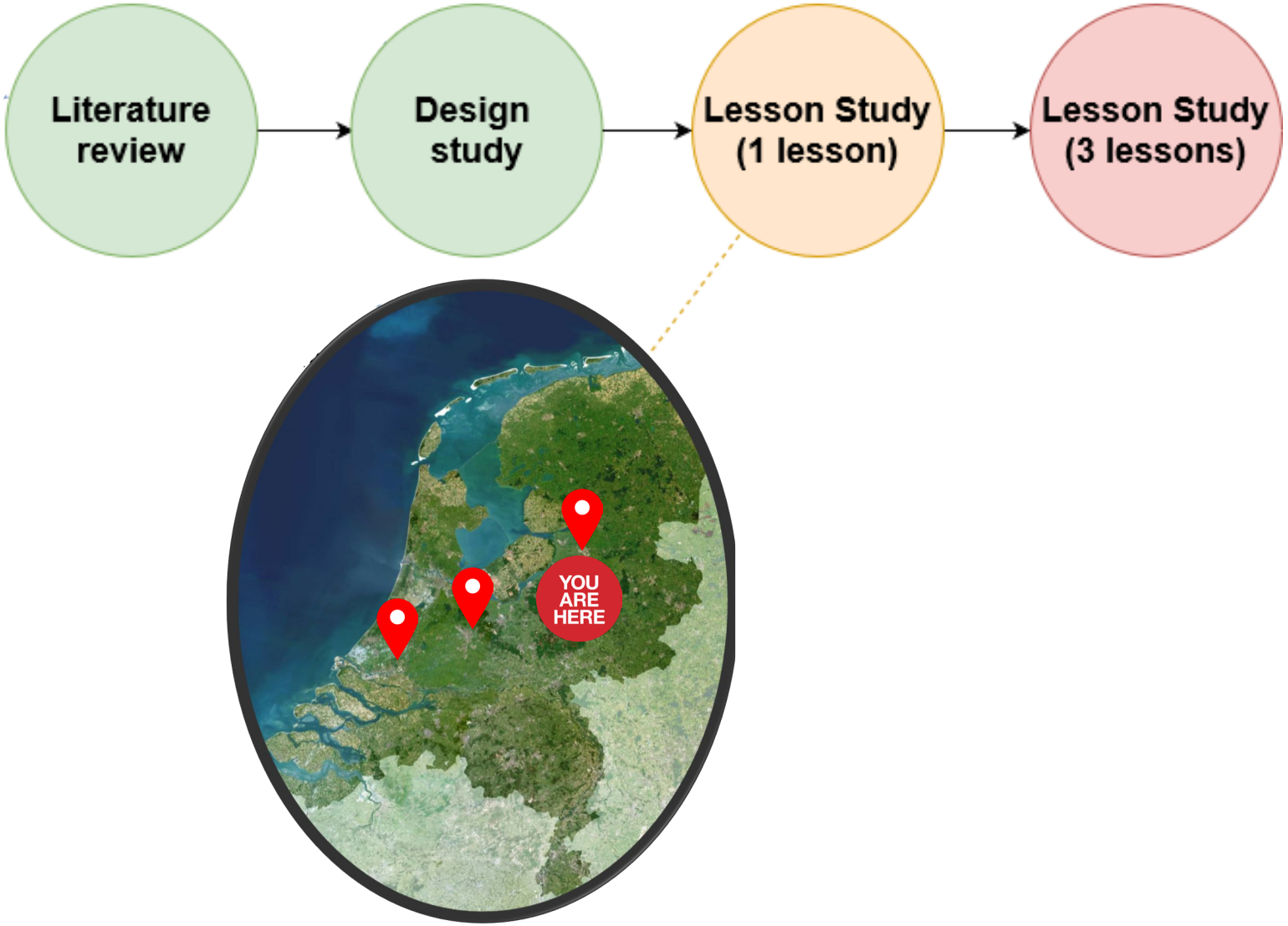
Research design



Research design

Lesson Study Team:

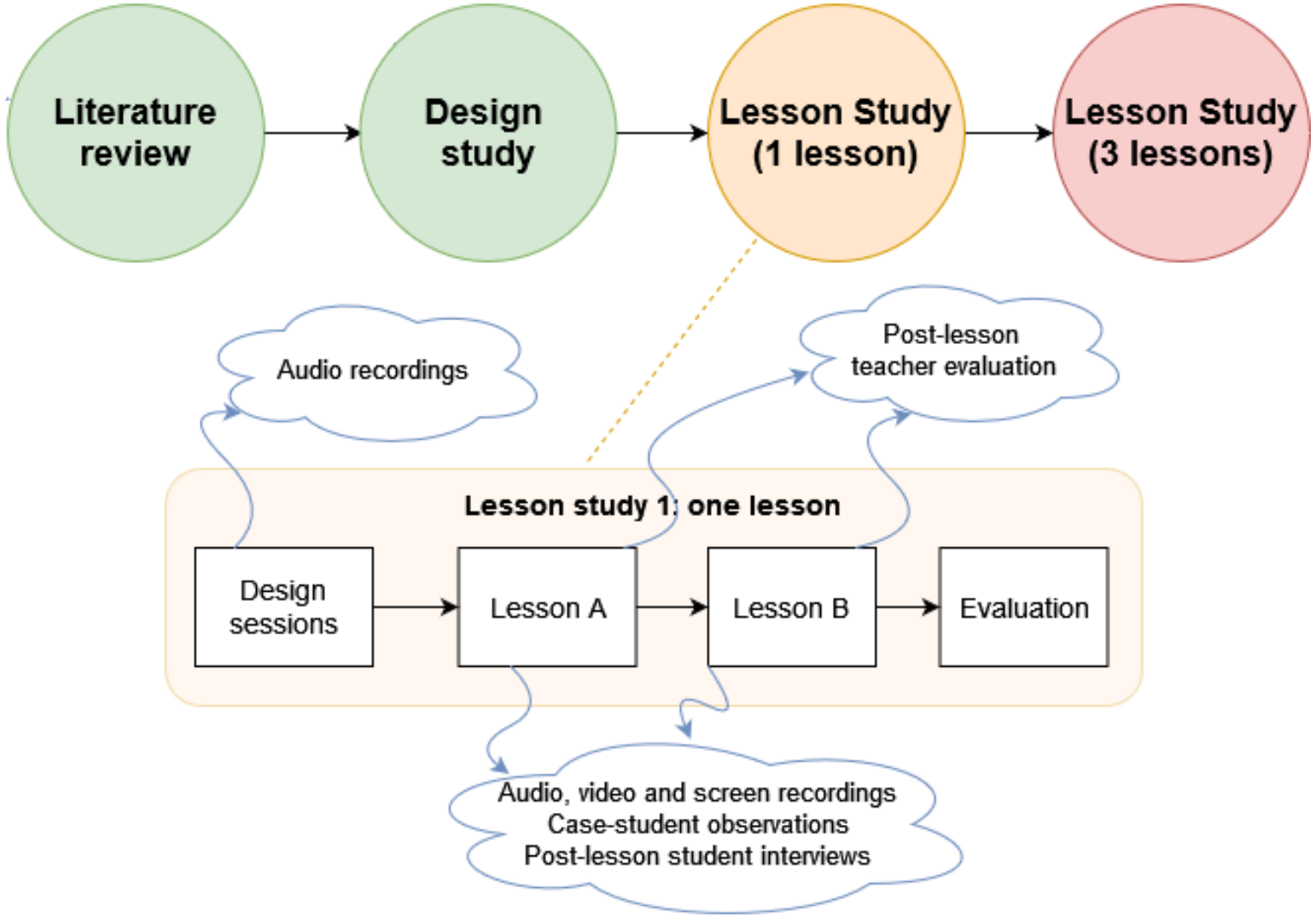
- 3 researchers from Utrecht University
- 2 teachers from Comenius College
- 1 teacher from CGU



Research design

Lesson Study activities:

- Five online **design meetings** (1.5h)
- **Lesson** (90 min) performed twice at *Teaching and Learning Lab* (UU)
- Case-student **observations** and **interviews**
- Post-lesson **evaluation** by students and teachers



Lesson design

- Learning objective: understanding the concept of **time dilation**
- Sparkle curiosity by posing a central **thought-experiment**
- Variation between **plenary discussion** and **simulation activities** guided by worksheets

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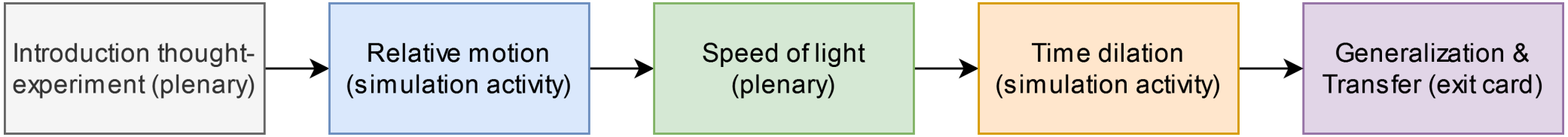
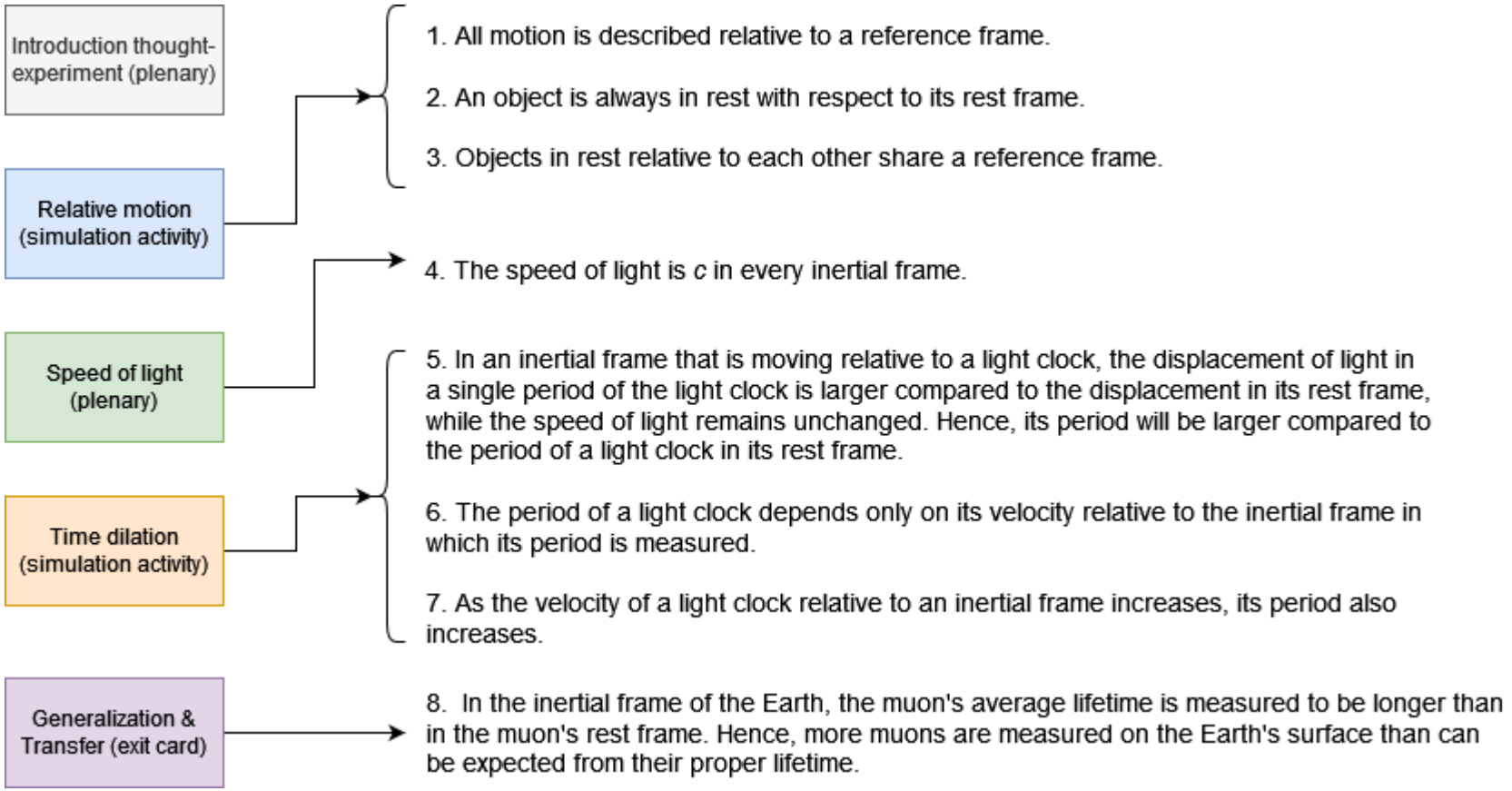


Lesson design

- Learning trajectory defined through 8 **key activities**
- Predicted **case-student behaviors** formulated for each key activity



Preliminary conclusions

- Each case-student followed a unique learning trajectory. Observed behavior was very different from predicted behavior.
- Exploratory talk often helped students to arrive at the correct conclusions.
- Students made little use of the available support structures (*i.e.* QR-codes).
- Students performed significantly better in the improved lesson.

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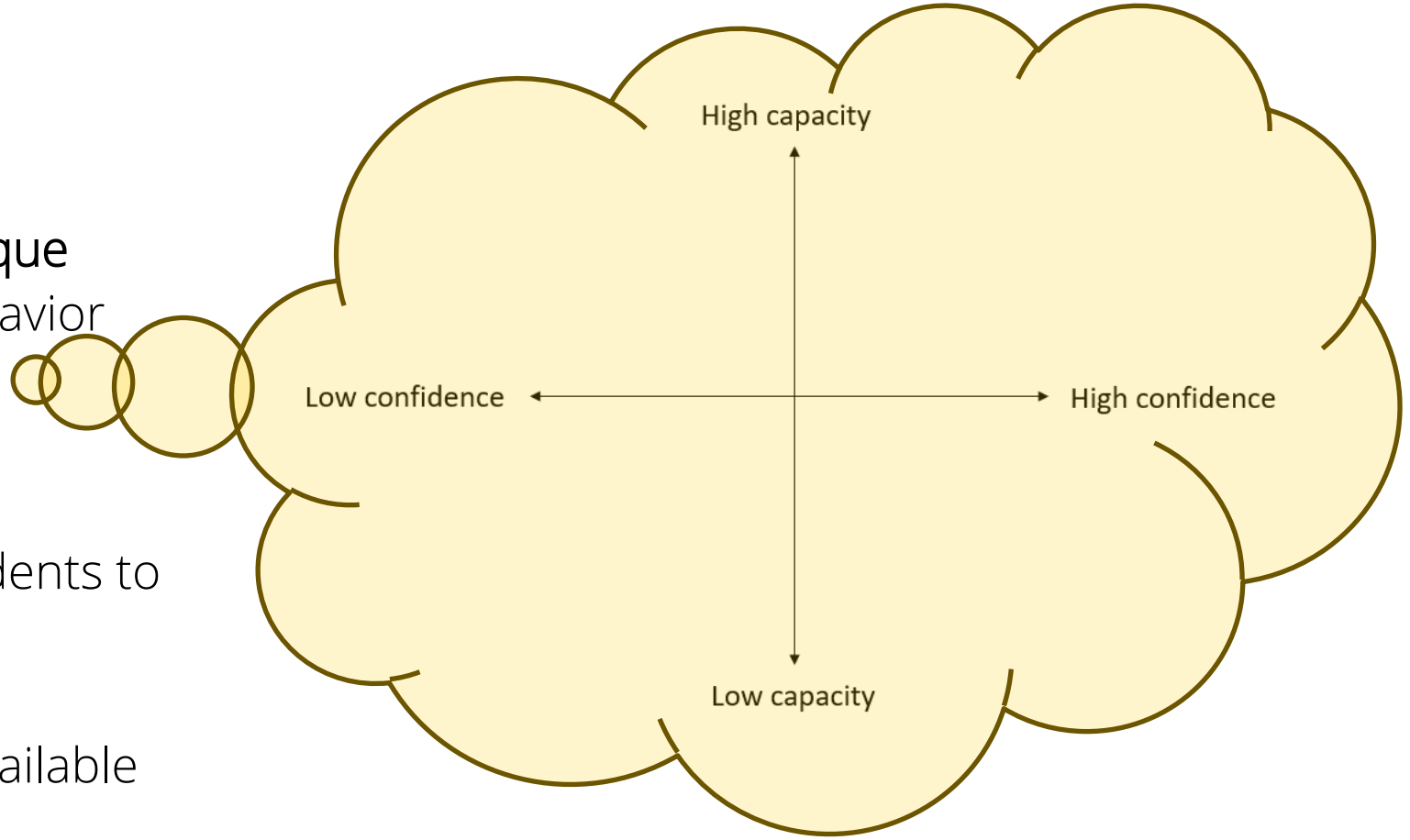
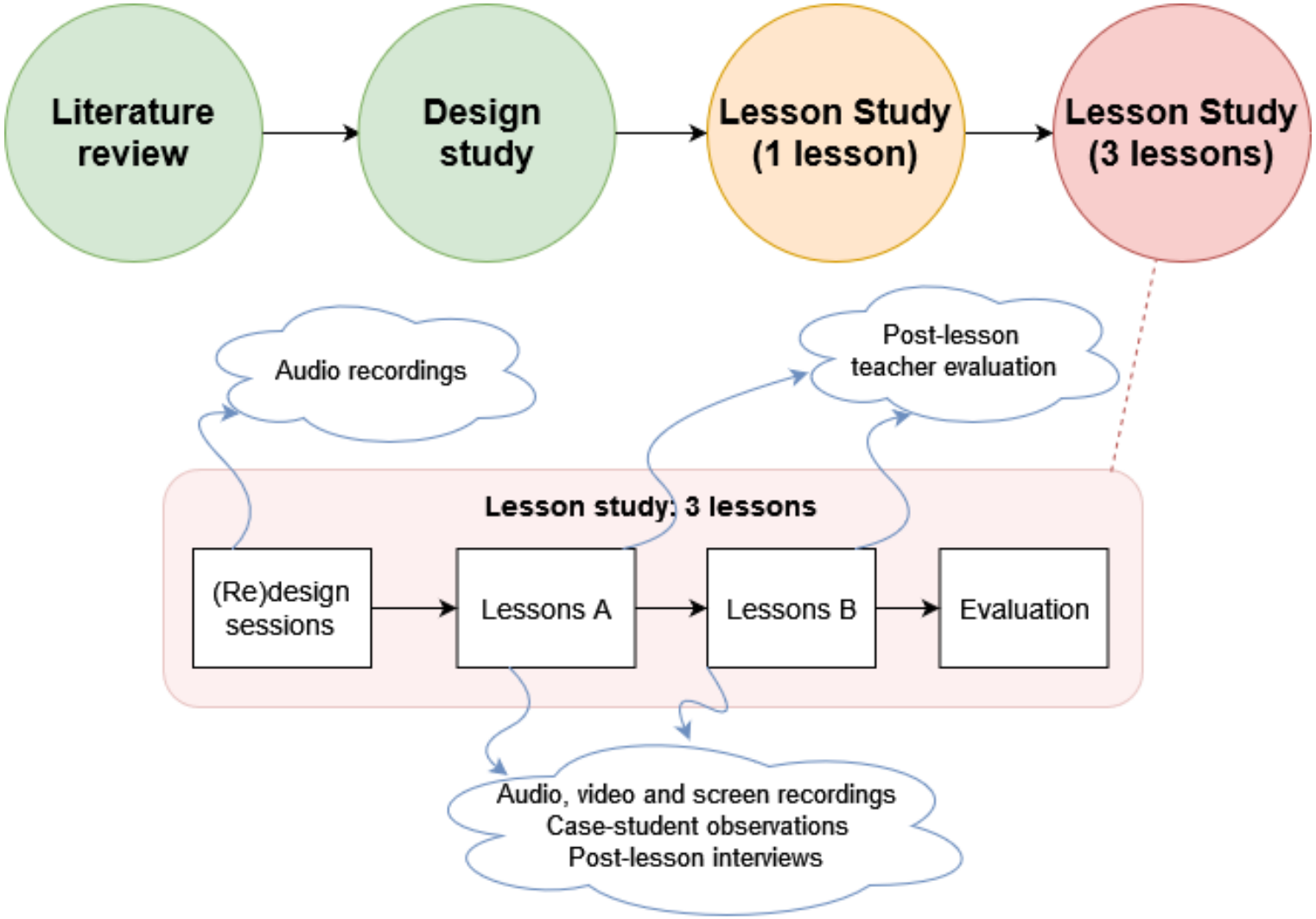


Next step

2nd cycle of Lesson Study:

- Extension to **three** 90 min lessons.
- Each lesson covers a section of the 1st Lesson Study cycle
- Performed **at the schools** rather than at the *Teaching and Learning Lab*.
- Stronger focus on **student understanding**.



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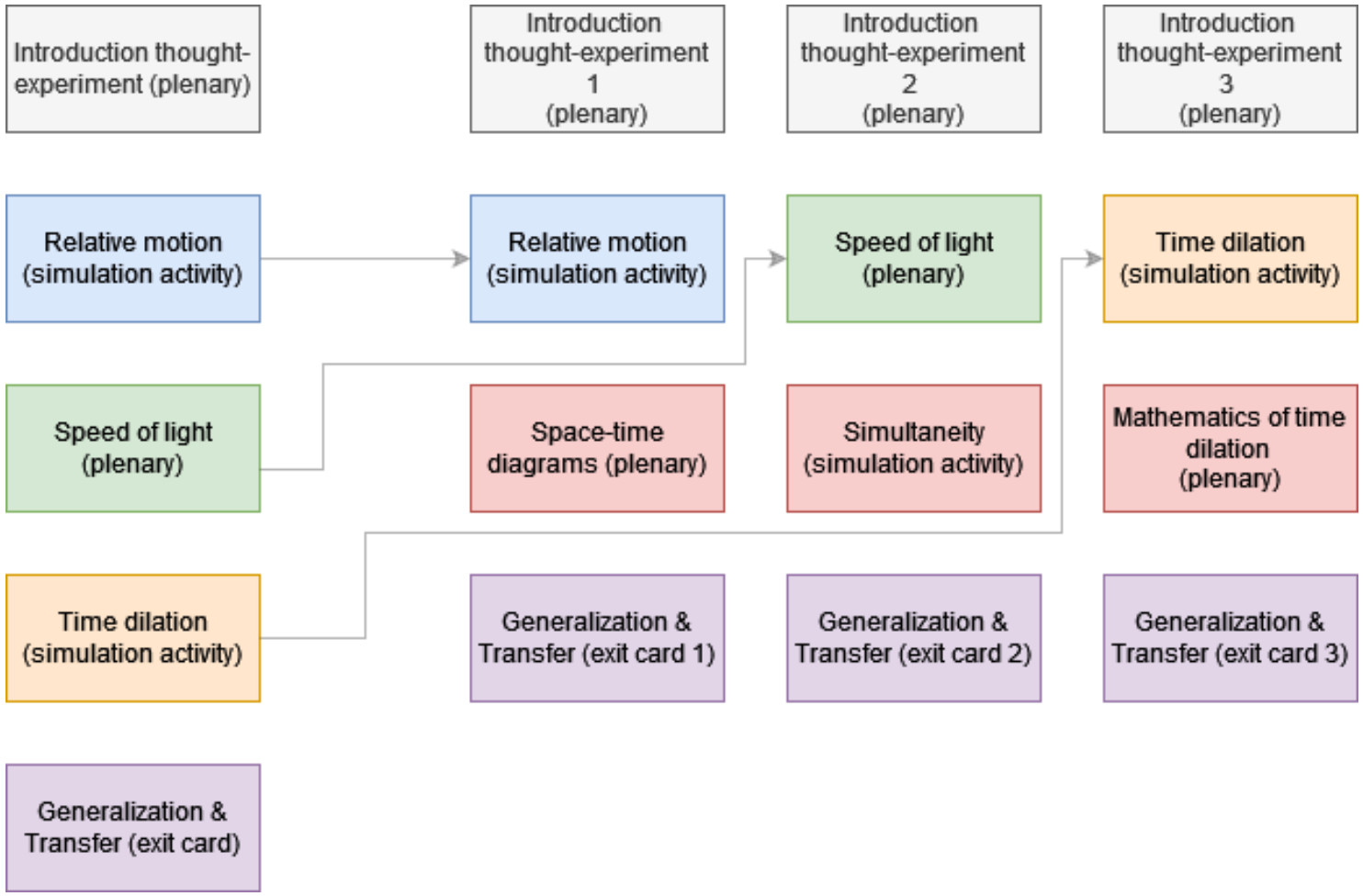
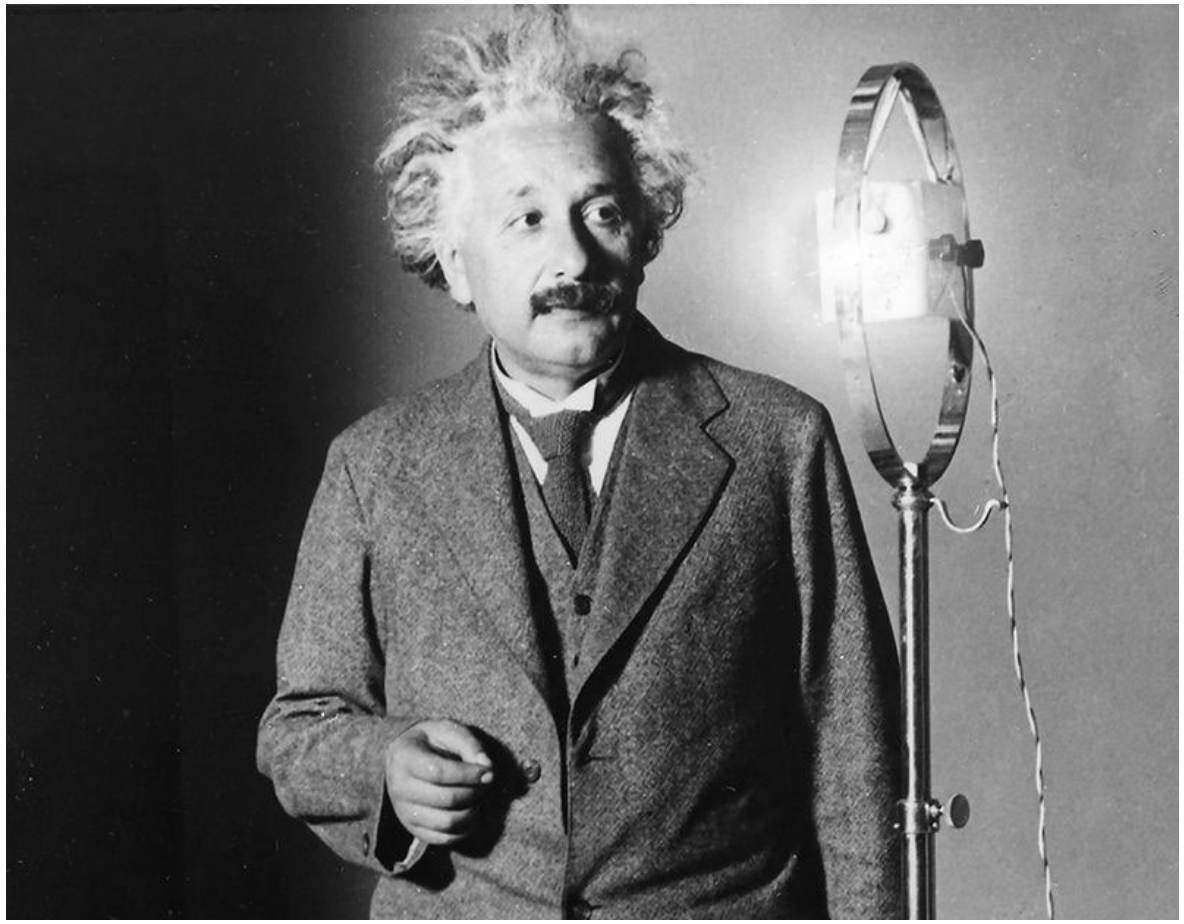


Thank you



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Case-student selection