Digitally aided experimenting in the context of the physics study entry phase

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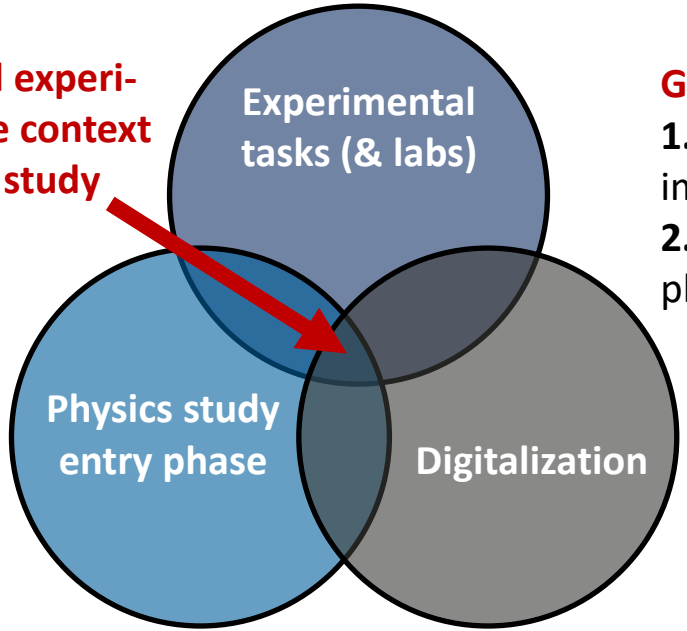
A cumulative PhD thesis (09/21-09/24) with a multi-perspective analysis of …

Digitally aided experimenting in the context of the physics study entry phase



Guiding question:

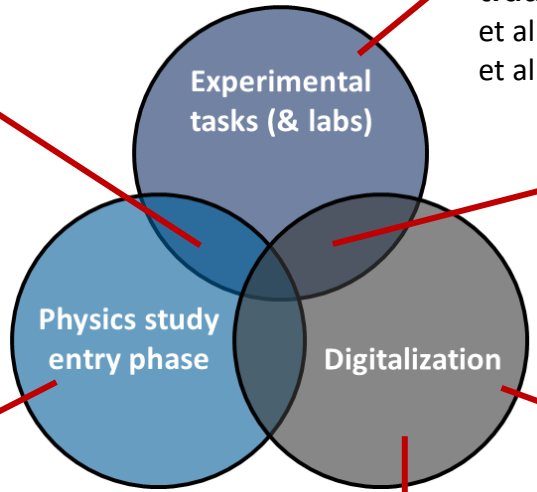
1. How can digitally aided experimental tasks be implemented in the physics study entry phase?

2. What does this imply for innovations in physics studies?

Motivation

Discussion of the (in-)effectiveness of traditional experimental tasks (e.g., Holmes et al., 2017; Holmes & Wieman, 2018; Teichmann et al., 2022; Rehfeldt, 2017; Haller, 1999)

Experimenting as a central scientific method of cognition, so experimental tasks are an important learning medium (Müller & Brown, 2022)



Experimenting/Labs under pandemic conditions (Hut et al., 2020; Jelicic et al., 2022; Werth et al, 2021)

Study entry phase challenging for many students, cf. high drop-out rates in physics (~60% in Germany) (Heublein et al., 2022)

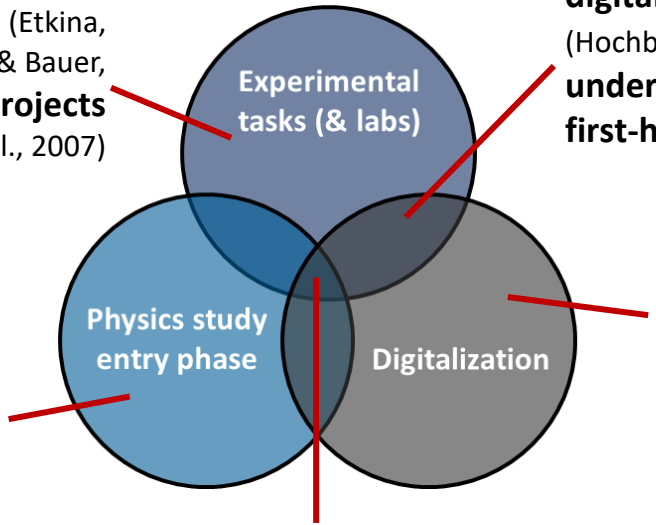
New arising digital technologies (smartphones, AI like ChatGPT)

Digital competencies as **new learning objectives** (Becker et al., 2020b)

State of research

High potential of open lab formats (Etkina, 2015; Holmes & Wieman, 2018; Sacher & Bauer, 2020; …), **like undergraduate research projects** (Ruiz-Primo et al. 2011; Russel et al., 2007)

Positive effects of experimenting with digital technologies, e. g. on motivation (Hochberg, 2016; Pirker, 2017) **& conceptual understanding** (Becker et al., 2020a) **allowing first-hand data collection** (Klein et al., 2021)



Research efforts about the context conditions in the study entry phase, e. g. requirement levels (Bauer et al., 2019), or reasons for dropping out (Albrecht, 2011; Heublein et al., 2022)

Variety of digital technologies utilizable for experiments (Gröber et al., 2017; Kuhn & Vogt, 2023; Thees et al., 2022; Theyßen, 1999; Thoms, 2019; Pirker, 2017; Schlummer et al., 2021; Staacks et al., 2018; Stampfer et al., 2020; …)

Work on implementation/evaluation of smartphone experiments in university education, e.g., in lectures (Staacks et al., 2022) or exercises (Hütz et al., 2017, 2019; Kaps et al., 2022; Klein, 2016)

Desiderata and goals of the thesis

Desiderata:

- **Holistic view on digitally aided experimental tasks in the study entry phase** considering existing contextual conditions and the effective structure of all actors
- **Particular focus on open investigation and undergraduate research**

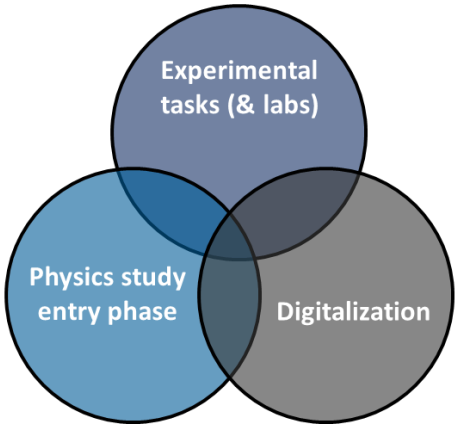
Development goal (DG):

Development & evaluation of digital experimental tasks for undergraduate research (projects)

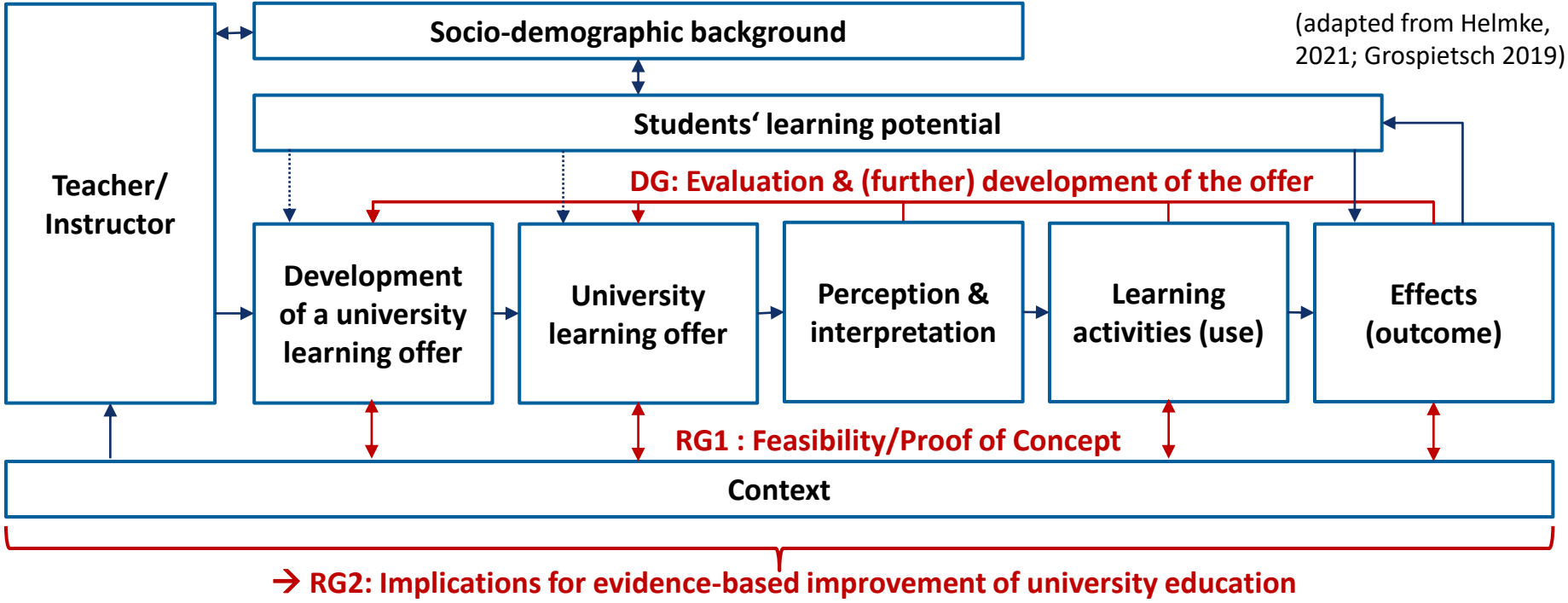
Research goals:

(RG1) Proof of concept/Feasibility study on the use of these tasks

(RG2) Implications for the evidence-based improvement of university physics education considering the displayed interplay

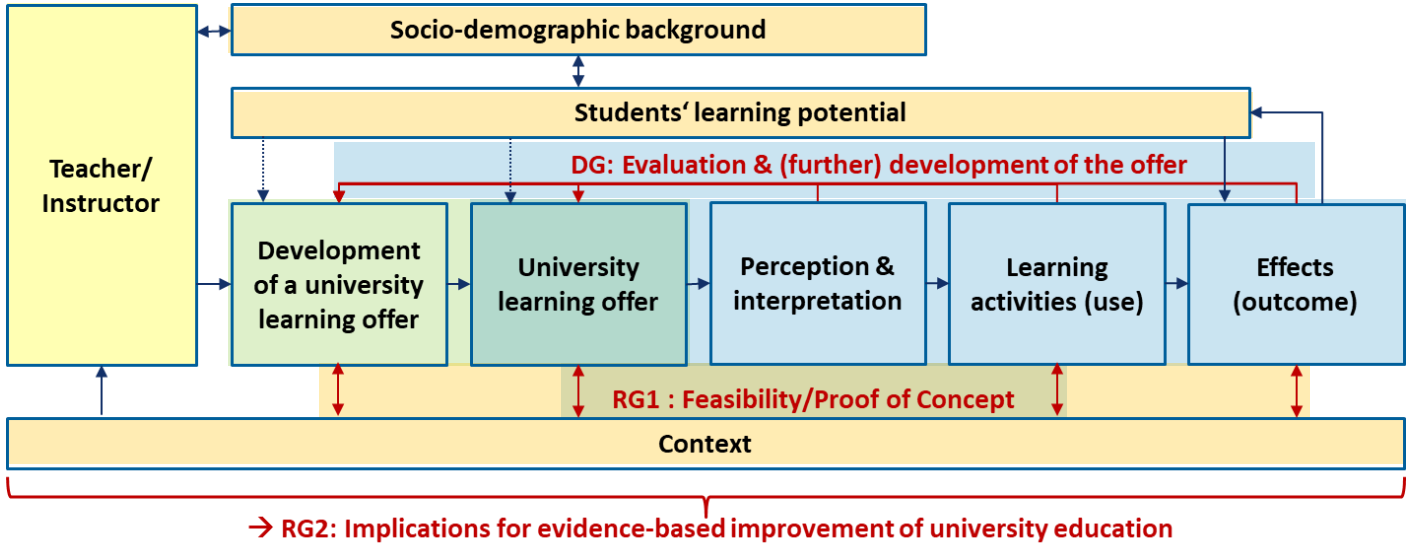


Theoretical & argumentative basis: the offer-and-use model



(adapted from Helmke, 2021; Grospietsch 2019)

Overview: 3 studies & development of experimental tasks



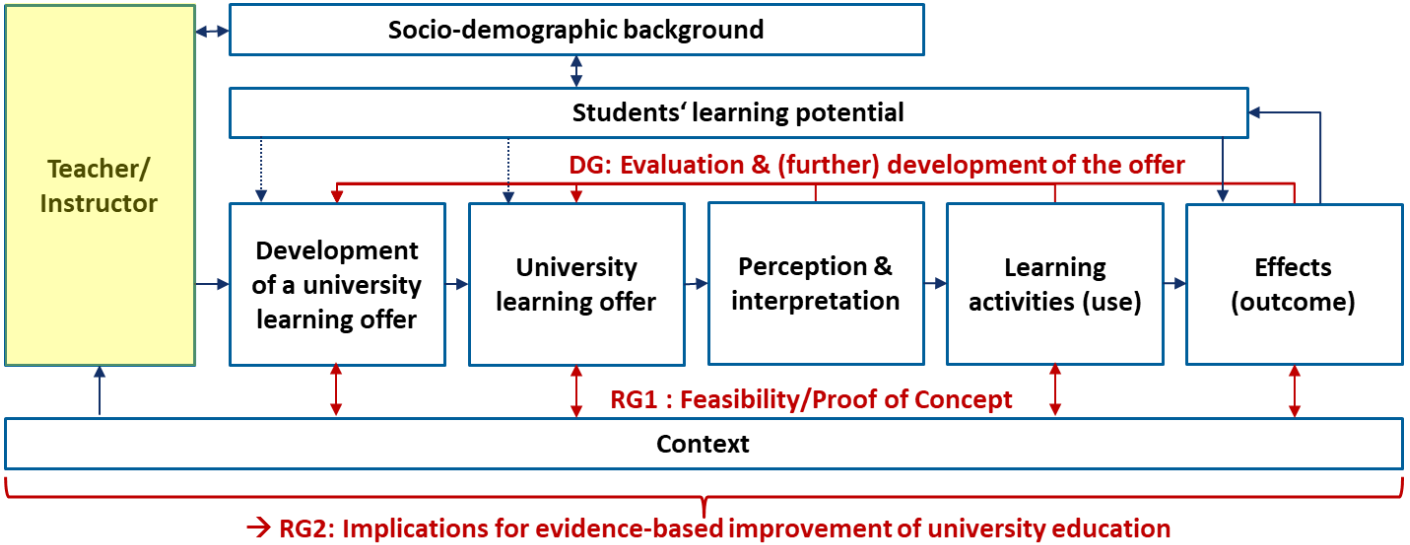
Study 1

Study 2

Study 3

Task development

Study 1: The instructors‘ perspective



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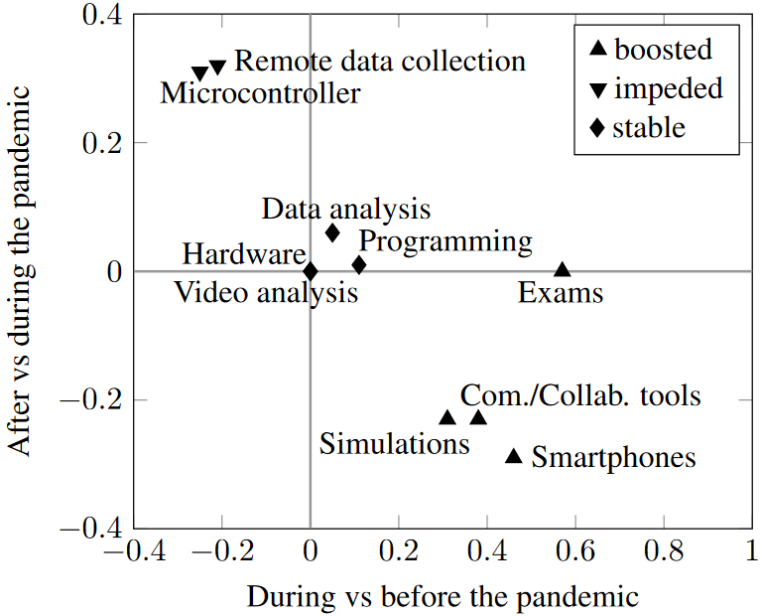
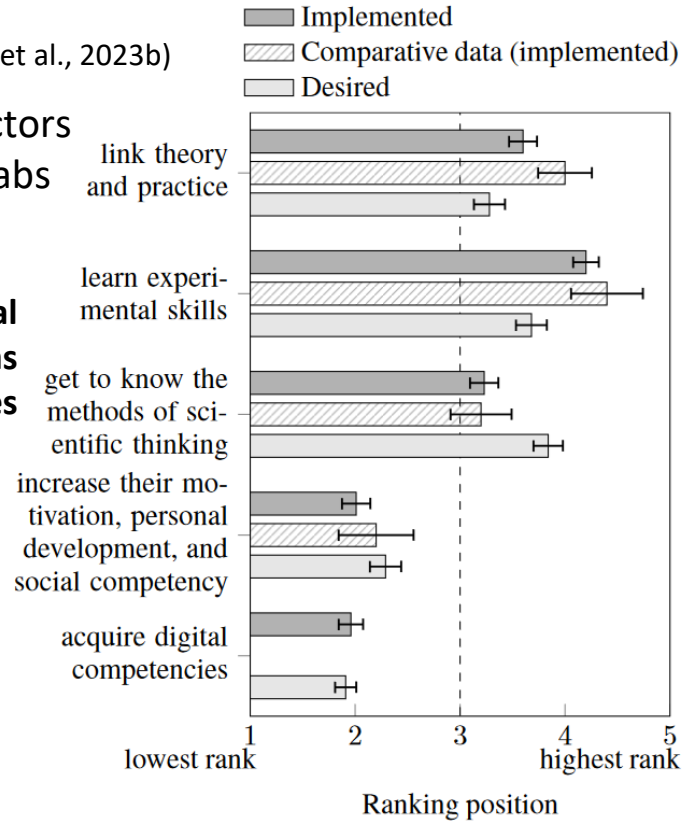
Study 1: The instructors‘ perspective (Lahme et al., 2023b)

- Survey among 79 German, Finnish, and Croatian lab instructors
- Status quo of digital technologies & learning objectives in labs

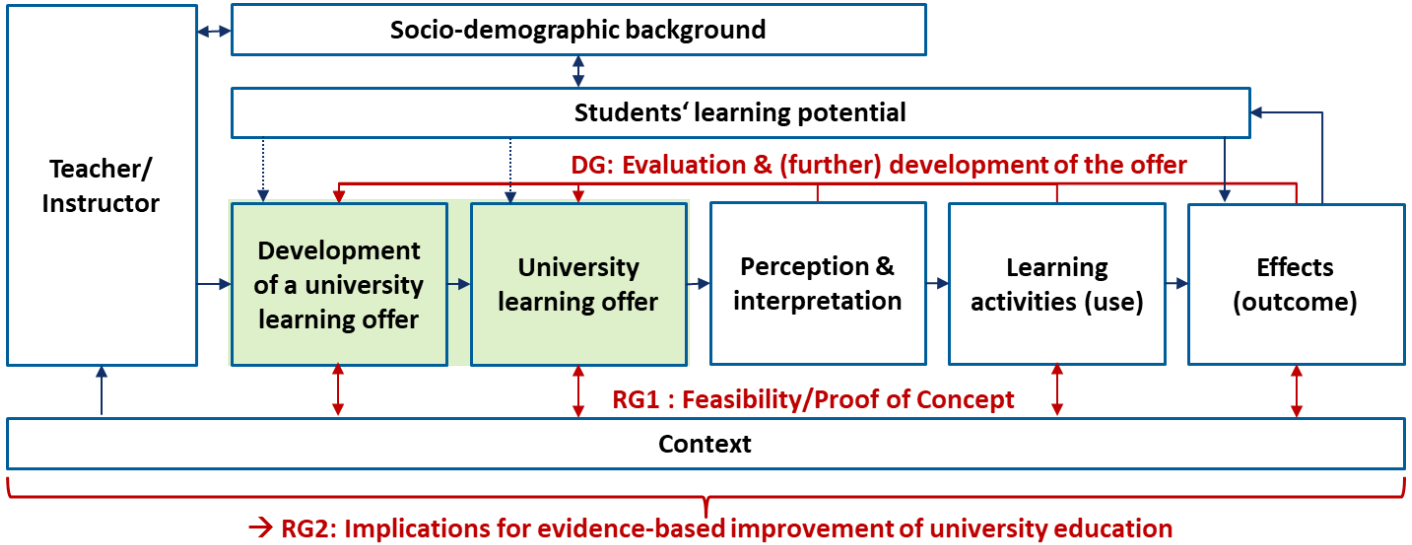


Change in the percentage of regular use of in their lab (if used)

Relevance of digital competencies as learning objectives



Development of smartphone-based experimental tasks



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Development of smartphone-based experimental tasks

Project 1: DigiPhysLab

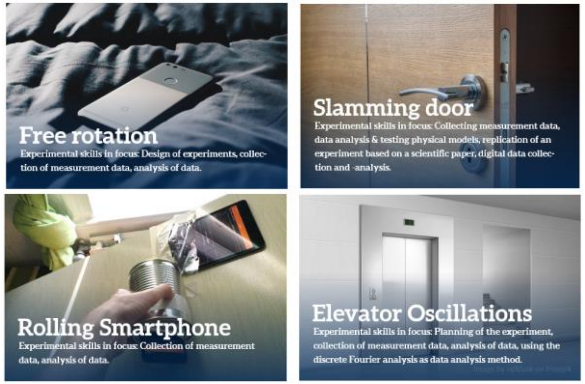
Co-funded by the Erasmus+ Programme of the European Union

JYVÄSKYLÄN YLIOPISTO
UNIVERSITY OF JYVÄSKYLÄ

UNIVERSITAS STUDIORUM ZAGRABIENSIS MDCLXIX

UNIVERSITÄT GÖTTINGEN

15 open experimental tasks for distance learning for ~2-4h each



6 tasks were adapted

Project 2: Innovation+

Niedersächsisches Ministerium für Wissenschaft und Kultur

6 experimental tasks for undergraduate research projects of ~2 months

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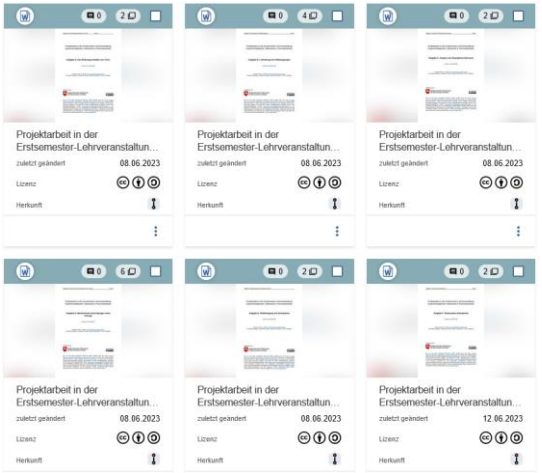
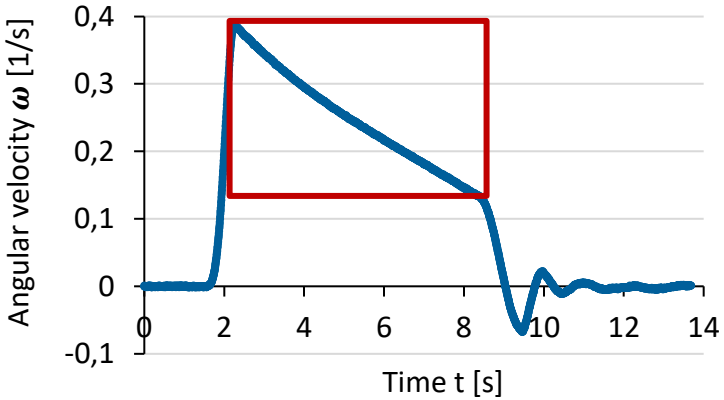


Development of smartphone-based experimental tasks - „The frictional behavior of doors“



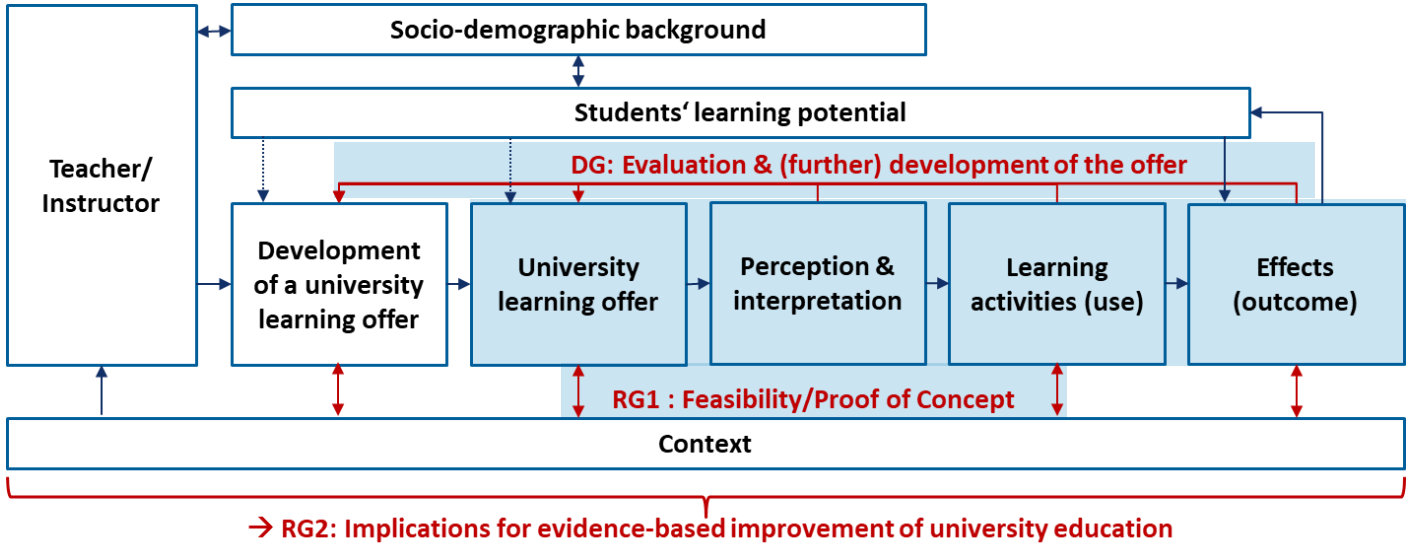
Fitting the data with models combining dry (D$\sim\omega^0$), Stokes (S $\sim\omega^1$) & Newtonian friction (N$\sim\omega^2$)

The task: **Develop an experiment in which you investigate the frictional effects** that occur when the door slams shut. To do this, **use** the sensors of **your smartphone**. Then, experimentally **answer** the question of **which friction model describes the slamming door most precisely** […]. Also, **take uncertainties** of measurement **into consideration**.

+ short motivation, guiding questions, learning objectives, references, recommended schedule, etc.

(Klein et. al., 2017; Lahme et al., 2022b)

Study 2: Undergraduate research projects in a first-year lecture



Study 1

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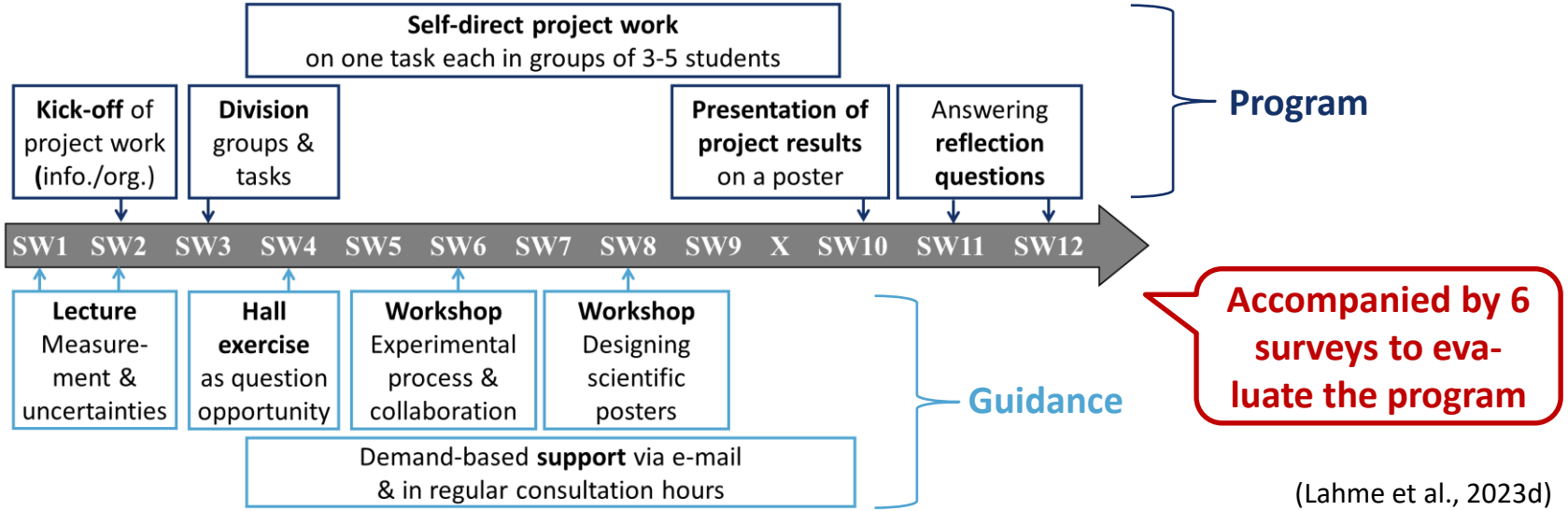
Task development

Study 2: Undergraduate research projects in a first-year lecture

- Implementation of the tasks in “Experimentalphysik I” at the University of Göttingen
- Fostering affective factors (e.g., curiosity, interest, sense of belonging) and self-regulated, crosslinking, inquiry-based learning

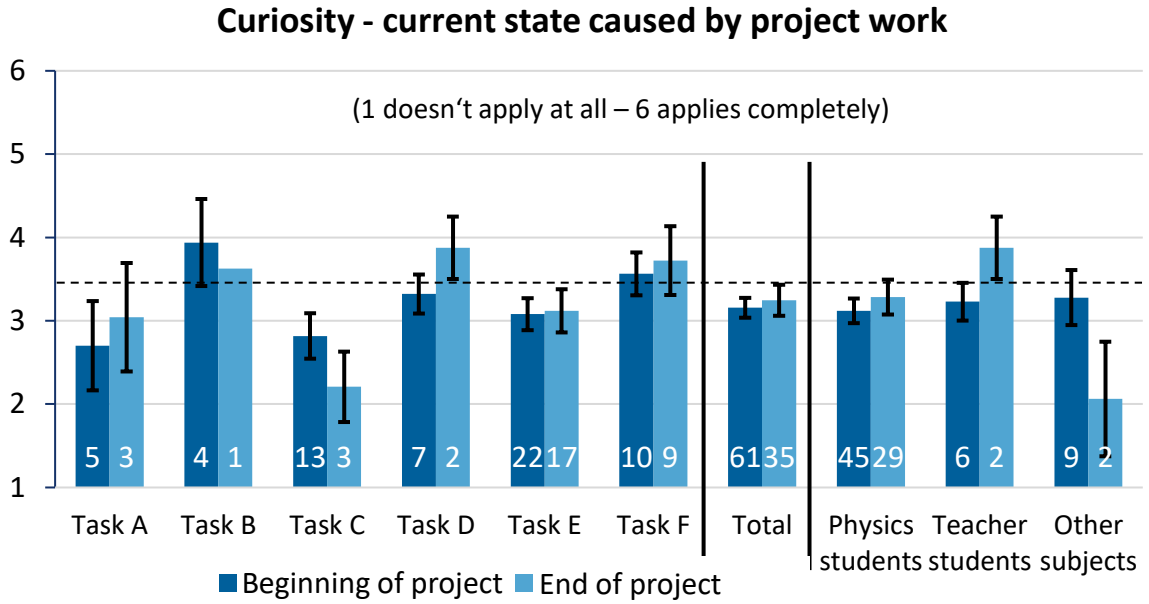


(Lahme et al., 2023d)

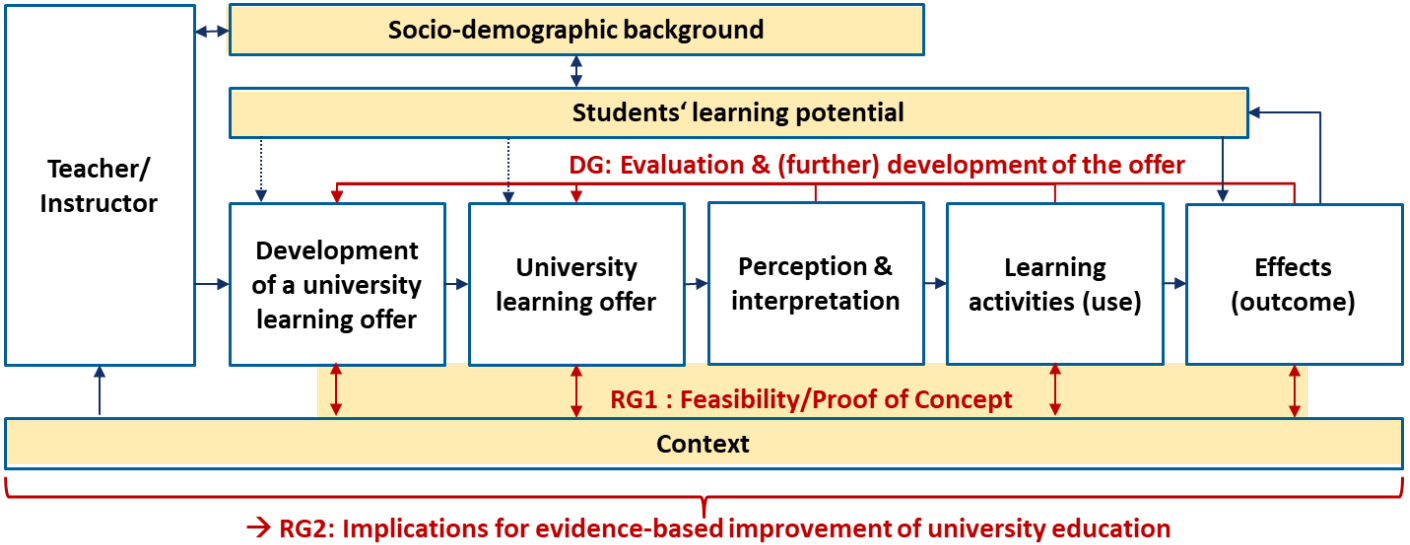
Study 2: Undergraduate research projects in a first-year lecture

What the students liked	What the students disliked
Open, free working/creativity	High affordance/ complexity
Use of smartphones	Not all tasks interesting
Exploring everyday physical phenomena	(Time) Effort / Pressure

(24,6±2,2) h



Study 3: Trajectory of stress in the physics study-entry phase



Study 1

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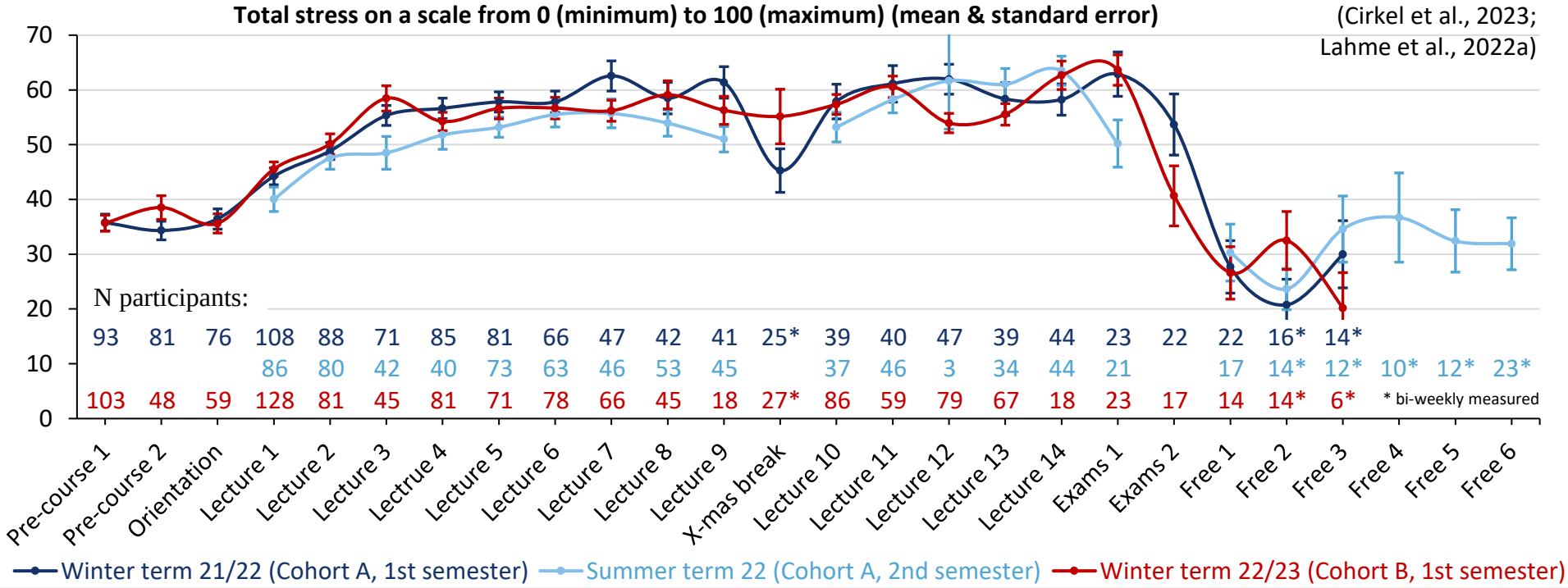
Task development

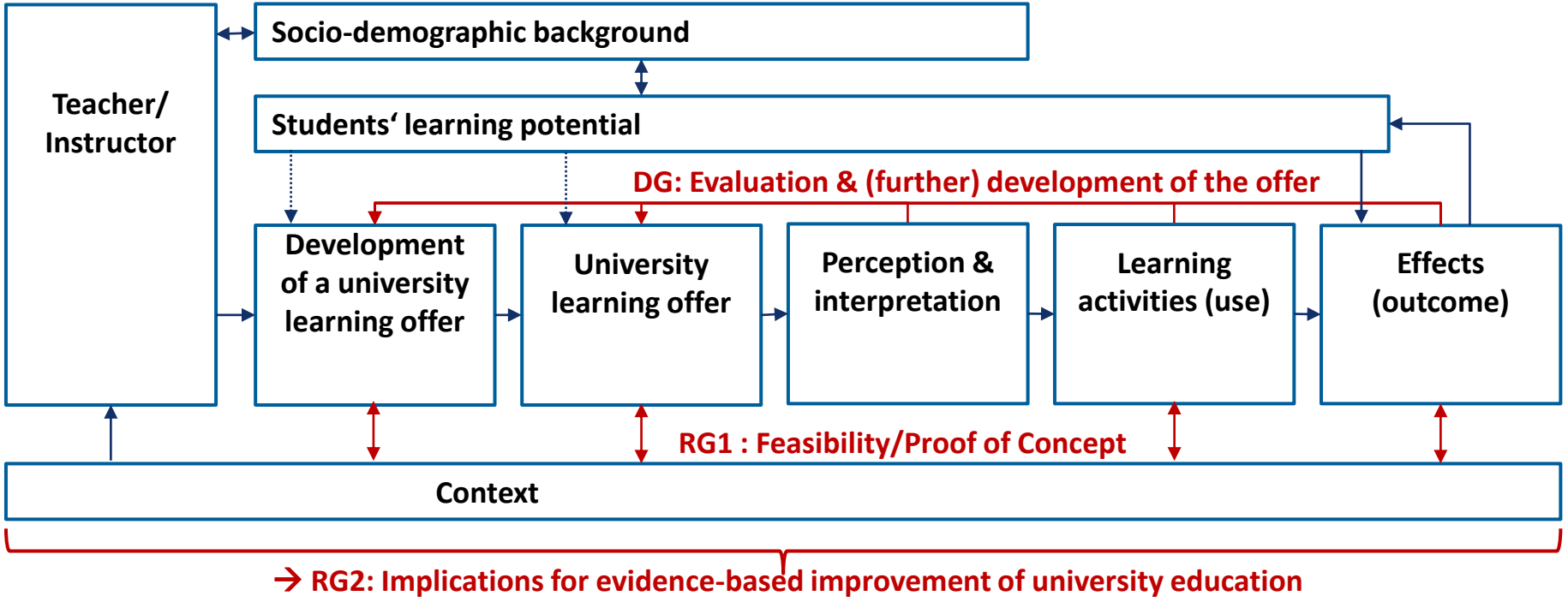
Study 3: Trajectory of stress in the physics study-entry phase

- **Investigation of the students‘ stress levels** (Fliege et al., 2001) and sources of stress
- **Panel study** over the first two semesters **with almost weekly measurements**
- Already in the second cohort (i.e., also a trend study)
- Additional consideration of the students‘ workload, mindset (Diederich & Spatz, 2021), sense of belonging (Feser & Plotz, 2023; Baumert et al., 2008), etc.

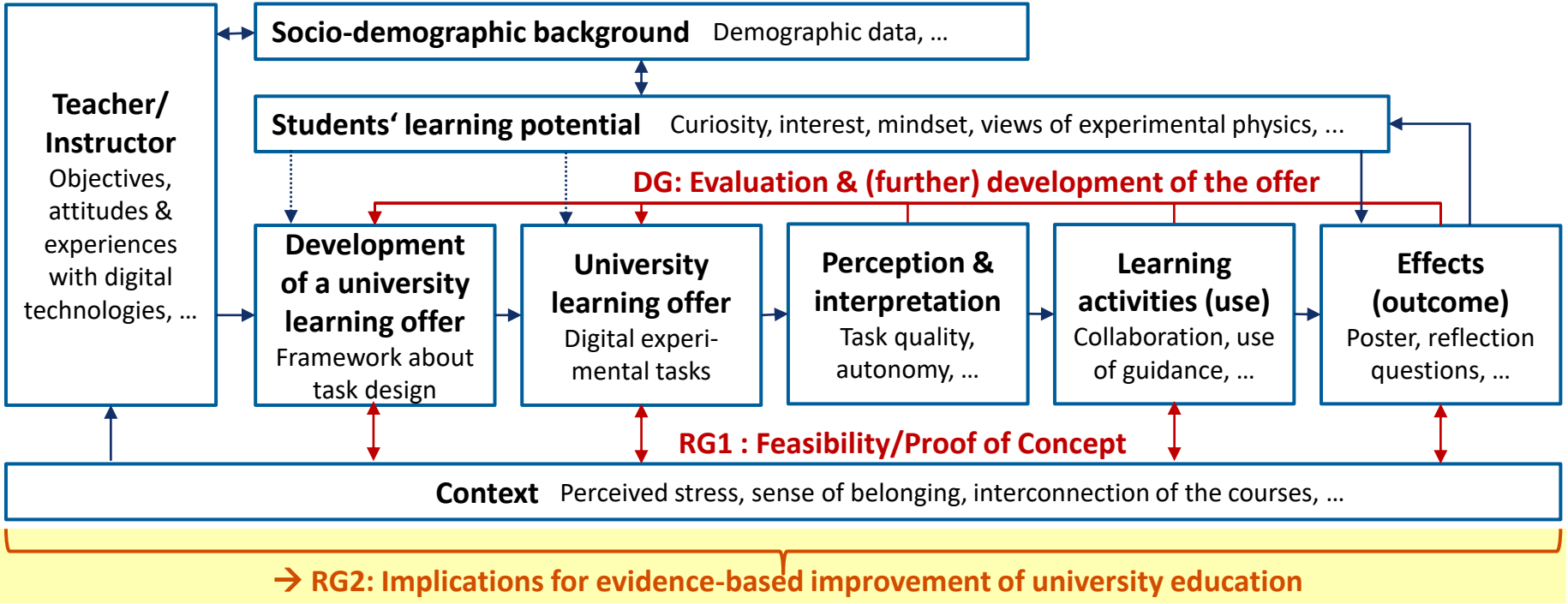
Study 3: Trajectory of stress in the physics study-entry phase



Integrative discussion based on an offer-and-use model



Integrative discussion based on an offer-and-use model



Summary

Guiding question:
1. How can digitally aided experimental tasks be implemented in the physics study entry phase?
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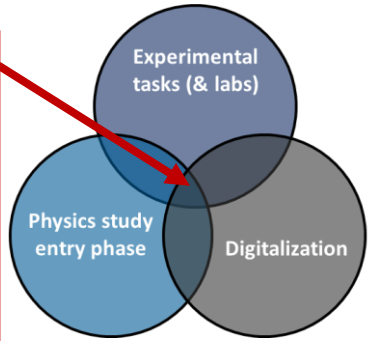

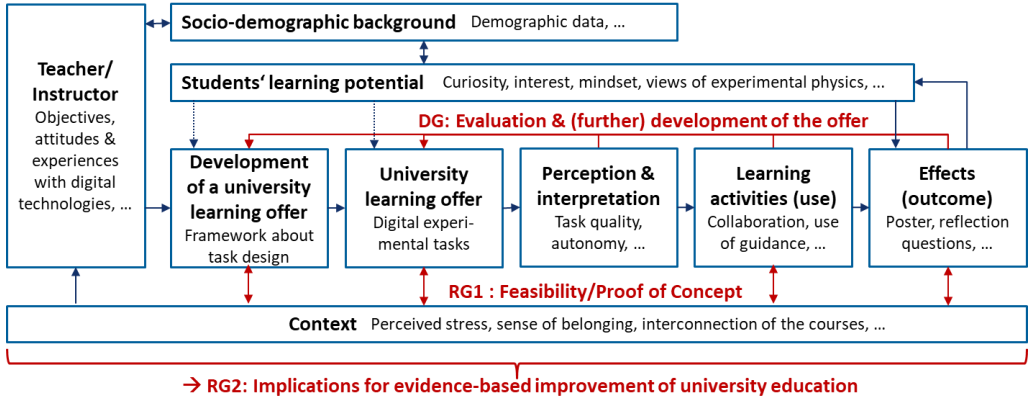

Aspects for feedback & discussion

1. Feedback on my reasoning: suitability of the offer-and-use model, coherence, …
2. Am I missing/ignoring any arguments/perspectives in my reasoning?
3. Which studies do you know that provide reference data for my discussion?
4. Do you have any tips for further data analysis and the integration of findings of the different studies to answer the guiding questions?
5. Which further investigation remains to be done from your perspective?

All task documents are available as OER:

https://jyu.fi/digiphyslab

https://doi.org/10.57961/49zr-w490

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