Smartphone-based undergraduate research projects in an introductory mechanics course

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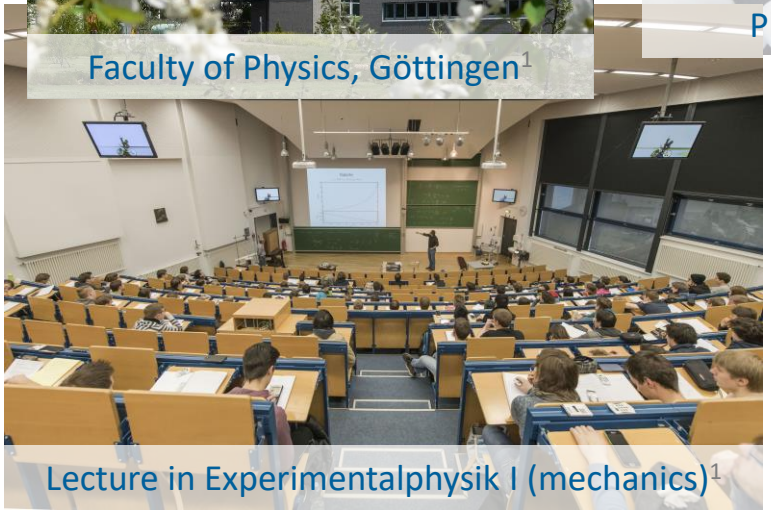
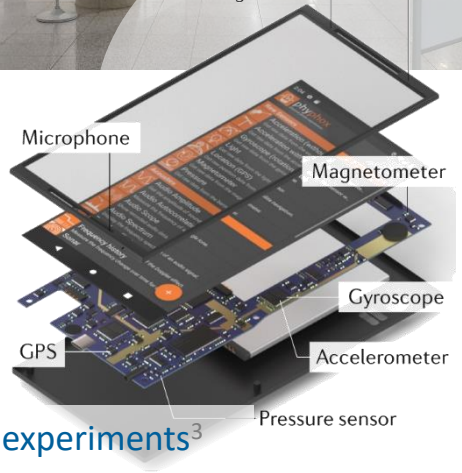
Physics lab course[2]

Group project work with poster session



Lecture in Experimentalphysik I (mechanics)[1]

Smartphone-based undergraduate research projects in an introductory mechanics course



Smartphone experiments[3]

[1] https://goepix.uni-goettingen.de/collection/2aaa145d-d59a-43e3-9d72-e77623f56ea6
[2] http://www.praktikum.physik.uni-goettingen.de/allgemeines/bilder/AP_06/images/HPIM2310.jpg
[3] https://doi.org/10.1038/s41578-020-0184-2

Motivation & Theoretical background

Challenging physics study entry phase (cf. high drop-out rates of 60% in Germany)[1]

Needed identity formation on 3 levels[2]: **1. subject content**, **2. metacognition** (self-directed learning, curiosity & interest) & **3. socialization** (university, peers & scientific community)

Labwork could provide learning opportunities - traditional experimental tasks are rather ineffective[3]

High potential of open lab course formats[4]

Especially undergraduate research projects (URPs)[5], **e.g., to foster higher-order thinking skills** (HOTs) like autonomy, curiosity, creativity or problem-solving[6]

Positive effects of experimenting with smartphones, e.g., on motivation[7] & conceptual understanding[8] while enabling first-hand data collection[9]

Already a lot of prior work on their implementation/ evaluation in university education[10]

[1] (Heublein et al., 2022); [2] (Bauer et al., 2019); [3] (Holmes et al., 2017; Teichmann et al., 2022; Rehfeldt, 2017; Haller, 1999); [4] (Etkina, 2015; Holmes & Wieman, 2018); [5] (Oliver et al., 2023; Ruiz-Primo et al., 2011; Russell et al., 2007); [6] (Mieg et al., 2022; Murtonen, & Balloo, 2019; Walsh et al., 2019); [7] (Hochberg, 2016); [8] (Becker et al., 2020); [9] (Klein et al., 2021); [10] (Staacks et al., 2022; Hütz et al., 2017, 2019; Kaps et al., 2022; Klein, 2016)

Overview of the Innovation+ project – Task development

DigiPhysLab

JYVÄSKYLÄN YLIOPISTO UNIVERSITY OF JYVÄSKYLÄ

UNIVERSITÄT GÖTTINGEN

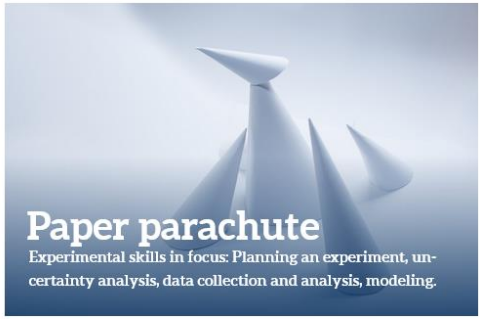
Co-funded by the Erasmus+ Programme of the European Union

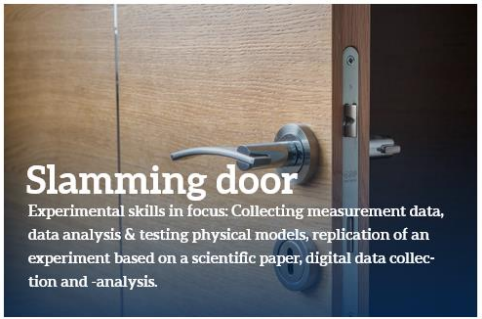
6 tasks were adapted

Innovation+

UNIVERSITÄT GÖTTINGEN

Niedersächsisches Ministerium für Wissenschaft und Kultur



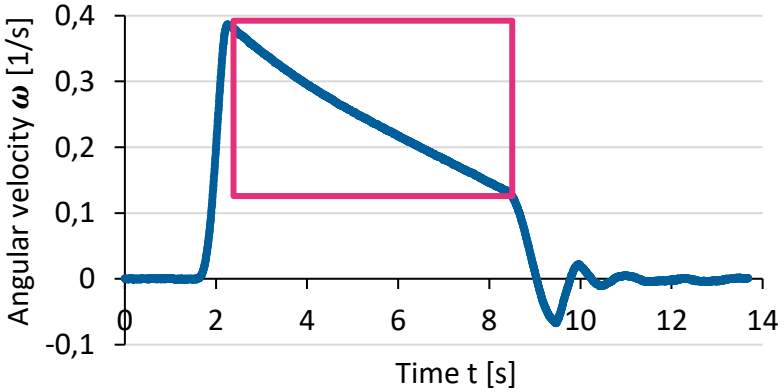


(Lahme et al., 2022a, 2023b)

Overview of the Innovation+ project – Slamming Door

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**.

+ guiding questions, literature references, …



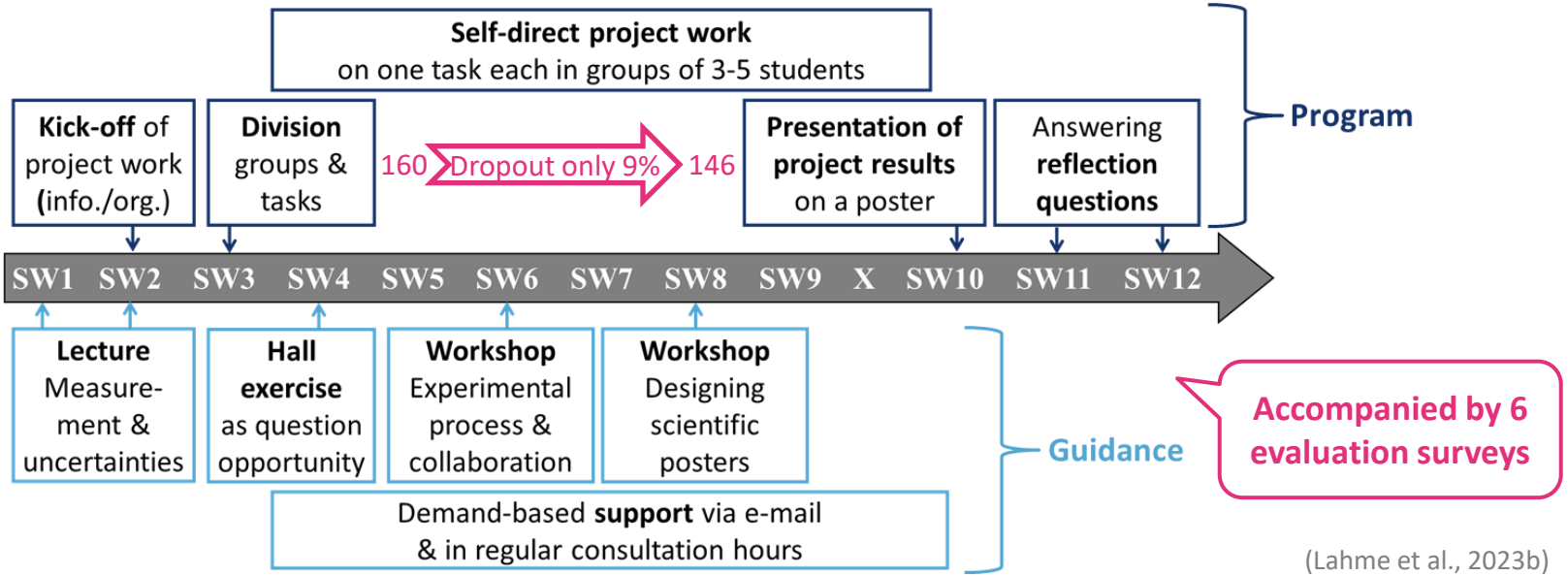
Fitting the data with models combining dry (D $\sim\omega^0$), Stokes (S $\sim\omega^1$) & Newtonian friction (N$\sim\omega^2$) based on the differential equation

$$a + b\omega + c\omega^2 = -I\dot{\omega}$$

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

Overview of the Innovation+ project – Implementation

Goal: Fostering affective factors (e.g., curiosity, interest, sense of belonging)
& self-regulated, inquiry-based learning



(Lahme et al., 2023b)

Insight in project evaluation

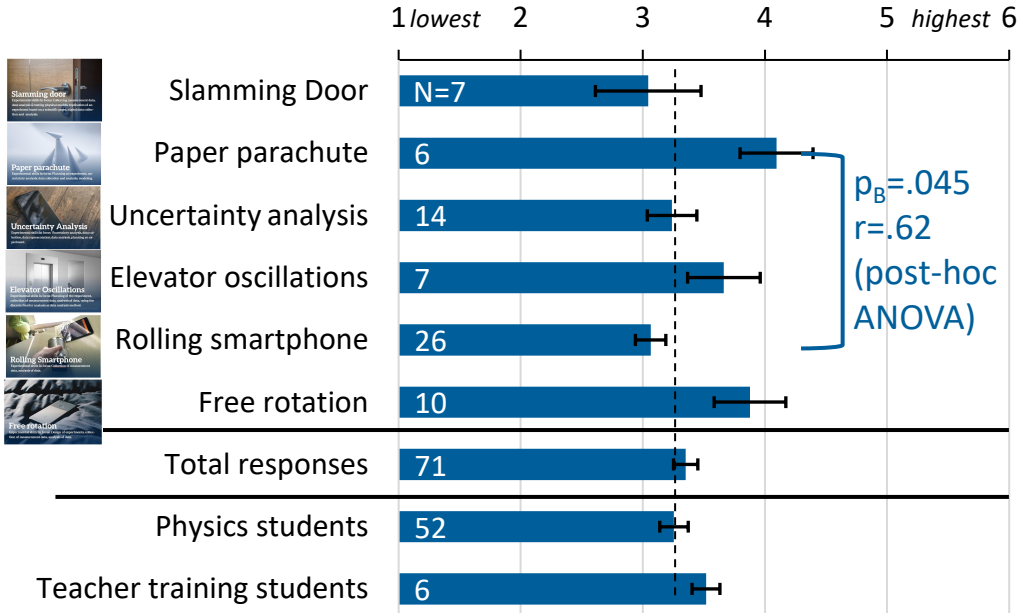
Most frequently mentioned aspects in questionnaire open text fields.

Average workload (24.6±2.2) h
- 25 h expected & compensated

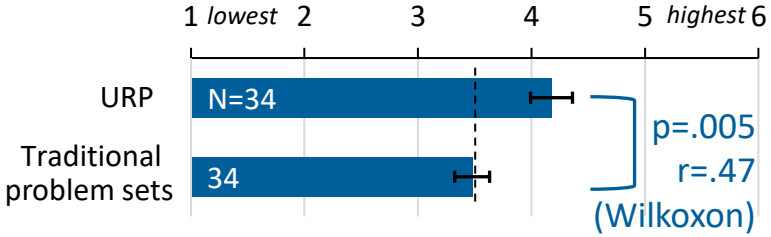
What the students liked…	N	What the students disliked…	N
Autonomy & creativity	27	Time requirement & time management	35
Collaborative group work	18	High/Additional effort/expenditure	30
Fostering competencies & experience of competence	16	Task not interesting/boring	23
Easy conduction with simple equipment	15	High degree of openness	17
Use of digital technologies	13	Difficulties within the project groups	16
Exploring everyday phenomena	12		

Insight in project evaluation

Interest caused by the URPs



Perceived autonomy



(Items: Klein, 2016)

Summary

- **Proof of concept** of the implementation of six experimental tasks as URPs
- **Impression of potentials and challenges & experiences with implementation** (e.g., higher autonomy, tasks differently interesting, addressing both target groups)
- **Basis for potential improvement** of tasks & the project implementation itself

Outlook

- **Further analysis** of quantitative questionnaire data and students' learning products
- **Comparison with findings** of other researchers (e.g., Kaps & Stallmach, 2022; Klein, 2016; Ruiz-Primo et al., 2011)

Undergraduate research project task documents as Open Educational Resources (OER) *in German & English*

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

Website of the presented project *in German*

https://www.uni-goettingen.de/de/657593.html

Website of the underlying Erasmus+ **DigiPhysLab-project** *in English*

https://jyu.fi/digiphyslab

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