Using STACK for pre- and supplement-course construction in Physics – a field report

K. Schmitt, V. Spatz

Physics Education Research Group, Technical University of Darmstadt

TECHNISCHE UNIVERSITÄT DARMSTADT

Theoretical framework

- Unchanged high drop-out in science and engineering studies at german universities: ~ 40% in physics (Heublein, Richter & Schmelzer, 2020)
  - Great heterogeneity in pre-university education
  - Self-reported reasons by students: content-related requirements (Albrecht & Nordmeier, 2011)

Special view on physics minors

- Students seem to struggle with the understanding of physical concepts
- Lectures are compressed in time and already assume existing knowledge in:
  - Mathematics: Integration & Differentiation, Vectors
  - Physics (basic school knowledge)

Supplement courses for physics minors

Pre course (~8 quizzes)
- Basic mathematical knowledge
- Basic knowledge in physics

Accompanying course (up to 15 quizzes)
- Contents of corresponding lectures and exercises

Implementation since 2020:
- Digital moodle-course for each lecture
- Self-regulated learning without live and predetermined sessions
- Test segments for each content (about 3-6 STACK-based tasks)

- Accessible one week before the beginning of the semester
- Accessible one week before content is dealt with in the lecture

Goals

1. Adjust prior-knowledge of students with different university-entrance qualifications (general qualification with (non)-advanced courses in physics/mathematics, vocational education, etc.)
   - Give students the opportunity to repeat/learn physics contents which are teached in school
   - Almost no opportunities are offered for physics in comparison to mathematics
     - ✓ Arithmetic
     - ✓ Conceptual understanding/knowledge
     - ✓ Application of formula and physical concepts within realistic situations
2. Offer a wide variety of digital self-learning content for different levels of prior-knowledge in mathematics and especially physics
   - Focus on high versatility and wide applicability in:
     - *1. how contents can be used, 2. why contents are used, 3. by whom contents are used*

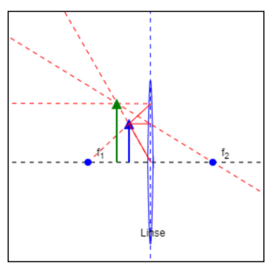
Physics for...
- Biology
- Electrical Engineering
- Mechanical Engineering
- Civil Engineering
- Chemistry

Course-design

Overall

$\eta = \frac{-\Delta W}{Q_H}$

Task formats:
- Multiple-Choice
- Calculation & algebraic input:
  - Evaluation and verification of physical units
  - Transposing and simplification of equations
  - Derivation of formula
- Graphical tasks & input via graphics: Implemented with JSXGraph



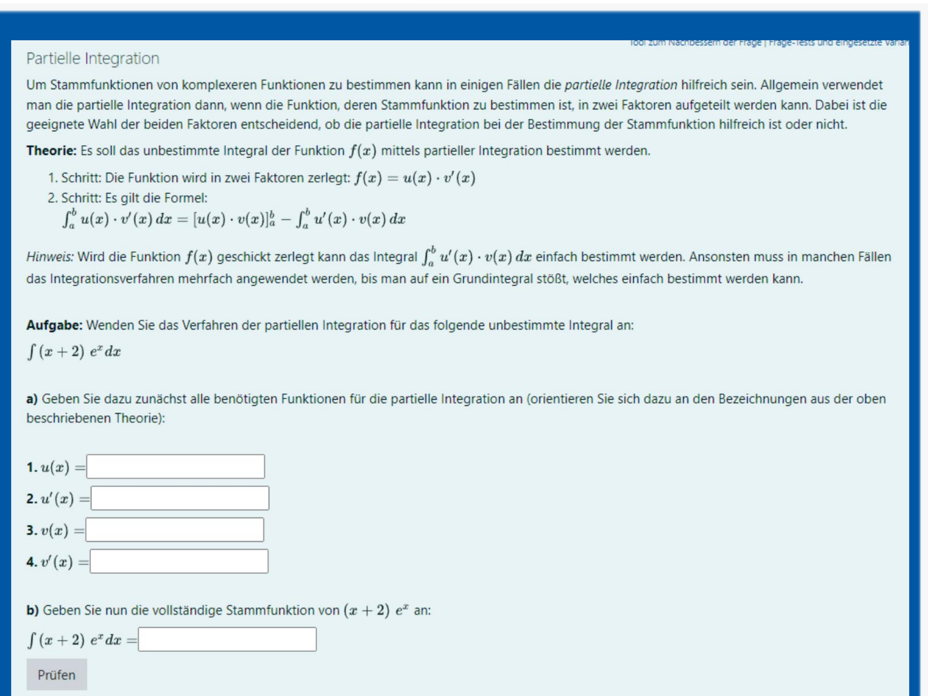
Different learning approaches for each content

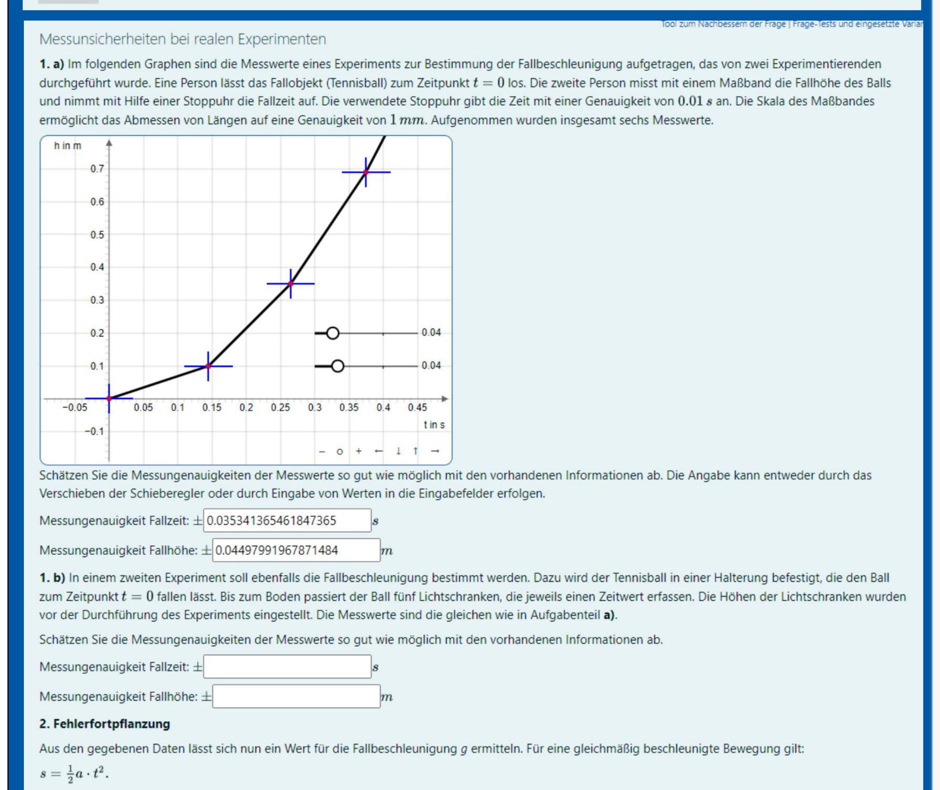
- Most tasks contain more than one task format:
  - Results in more complex tasks
  - Not only one aspect of a concept/formula is tested

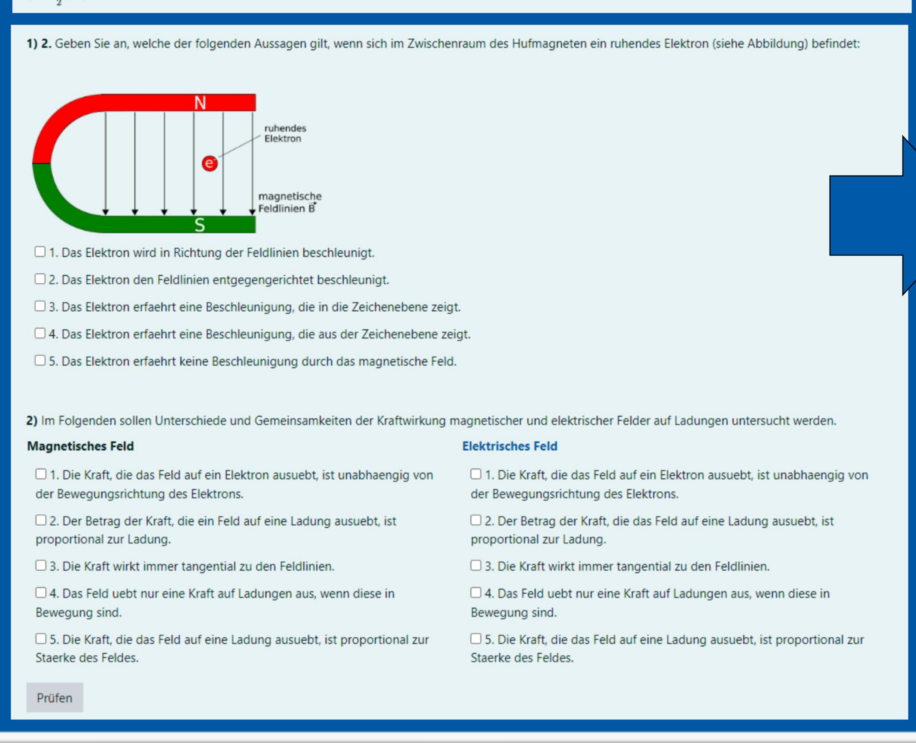
  → extensive tasks (e.g. text heavy)
- Tasks within one test build up on each other → immediate feedback after each task is provided

Intended usage

- Fully self-regualted: no live or active support and sessions while learning with the courses (E-Mail or forum post possible)
- Repeatable tasks with randomized numbers for exam preparation and feedback about what has been learned
- Preparation and catch up on lectures
- Self assessment of present prior knowledge
  → Partial response trees give the opportunity to adress different levels of prior-knowledge and misconceptions
- (inter)active supplementation of lectures
- Creation of real experimental situations







Practical experience

Participation
- Course got established since the first implementation
- Pre-Course: around 50% of registered users in a lecture

→ ~ 300 users per semester, depending on how many lectures are offered
- Accompanying-Course: around 10% with a descending trend during the semester

→ Increased usage for exam preparation

Usage in practice
How the service is used in practice

Majority
- Before first lecture (prior-knowledge)
- After last lecture (exam)

Minority:
- Postprocessing of the weekly lectures and contentes

Feedback from students
Wishes for future application

Pros:
- Direct connection between visualization of complex contents and abstract mathematical formula
- Consequential errors within multi-level tasks are noticed and are correctly included in the assessment
- Some tasks are close to exam tasks

Cons:
- Too few calculation tasks, especially with view to exam preparation
- User handling seems complex for some students
- Content related hints are missing

→ Course contents only show full solution

1. Step
First attempt: activation of prior-knowledge

2. Step
Immediate feedback:
- Specific
- General

Remember/repeat contents

3. Step

Acknowledge misconceptions

Learn (new)...
- Contents
- Formula
- Concepts
- Basics of physics

Future outlook

Course design related:
- More instructions for tasks
  - Hints
  - More detailed introduction (f.e. mathematical input)
- Overall more tasks for existing contents

Project related:
- Cooperation with other universities
- Provision of a high variety, quality assured database

Contact:

Kevin Schmitt
Scientific employee
Physics Department TU Darmstadt,
kevin_richard.schmitt@tu-darmstadt.de

Prof. Dr. Verena Spatz
Junior Professor
Physics Department TU Darmstadt,
verena.spatz@tu-darmstadt.de

Literature:

Heublein, Ulrich; Richter, Johanna; Schmelzer, Robert (2020): DZHW-Brief 03|2020 - Die Entwicklung der Studienabbruchquoten an den deutschen Hochschulen. In: *DZHW Brief* (03).

Albrecht, André; Nordmeier, Volkhard: Ursachen des Studienabbruchs in Physik. Eine explorative Studie.

Funded by

HessenHub
Netzwerk digitale Hochschullehre Hessen

HESSEN
Hessisches Ministerium für Wissenschaft und Kunst