## ETHzürich



STACK at ETH, Zürich - work in progress Meike Akveld \& Andreas Steiger, ETH Zürich

## About us



Meike Akveld
teaches a mandatory calculus class for 300 civil engineers


Andreas Steiger
teaches a mandatory calculus class for 700 mechanical engineers

## Overview

－Short history
－Results so far
－Future goals

## Short history

- Spring 2021: ETH sets up a test server with Moodle with the STACK module, Meike starts using STACK questions in multi-variable calculus for

Meike Akveld, akveld@math.ethz.cl Andreas Steiger, asteiger@math.ethz. civil engineers (on a voluntary basis).

- Fall 2021 / Spring 2022: STACK is available in the main ETH Moodle and is used in two large calculus classes (Civil and Mechanical engineers). Around 1000 students in total.
- STACK is now used for two purposes: To offer practice materials, and as a grade bonus which is obtained by solving weekly STACK questions.


## Some results I

STACK is used on two occasions in the Analysis I / II course for civil engineers
Meike Akveld, (around 300 students):

- As extra practice material (with random components).

```
Tool zum Nachbessem der Frage | Frage-Tests und eingesetzte Varianten
Bestimmen Sie das skalare Linienintegral }\mp@subsup{\int}{C}{}f\textrm{d}s\mathrm{ für
f(x,y)=x+y und den Kreis C mit Mittelpunkt (2,0) und Radius 2.
\mp@subsup{\int}{C}{}f\textrm{d}s=\square
Prüfen
```


## Some results I-Grade bonus

- To earn a grade bonus, students need to answer a one-question-quiz every week with a set time limit and under supervision. They get 0 or 1 point

Meike Akveld, akveld@math.ethz.ch Andreas Steiger, asteiger@math.ethz. based on correctness. This used to be done on paper.

- Maximum bonus achieved with 18 out of 24 questions solved correctly over the year.
- STACK questions aimed at practicing the most important computations of the course

Bestimmen Sie Menge aller Nullstellen des Polynoms $P(x)=x^{3}+9 \cdot x^{2}+15 \cdot x-25$.
Achtung: Bitte schreiben Sie Ihre Antwort in der Form $\left\{x_{1}, x_{2}, x_{3}\right\}$ also z.B. $\{8,9,10\}$ usw.
$\square$
Prüfen
First STACK quiz in the course (zeroes of a polynomial)

## Some results I - Numbers

Percentage of correct answers
Fall 2020 (on paper) vs Fall 2021 (STACK)


- On average 235 participants or $83.1 \%$ of all students.
- Success rate improved from $60.1 \%$ in 2020 to $65.4 \%$ in 2021.


## Some results II

STACK is also used in the Analysis I / II course for Mechanical engineers with

Meike Akveld, akveld@math.ethz.cl Andreas Steiger, asteiger@math.ethz.

- Students have to solve the weekly STACK question correctly, but they can try again with new parameters if they failed
- Maximum bonus achieved with 9 out of 12 questions solved correctly in each term
- STACK questions aimed at practicing the most important computations of the course
- Open problem: Many students hand in empty solution during first try, to see the solution


## Some results II - Sample question

Sei $S$ die Oberfläche des Würfels

$$
W=\{(x, y, z) \mid 0 \leq x \leq 1,0 \leq y \leq 1,0 \leq z \leq 1\}
$$

abzüglich der Seitenfläche in der $x y$-Ebene, also ohne Punkte mit $z=0$.
Wir berechnen den Fluss des Vektorfelds

$$
\vec{v}(x, y, z)=\left(\begin{array}{c}
x+6 \\
4 \cdot y^{2}+1 \\
2 \cdot z^{2}+1
\end{array}\right)
$$

durch $S$ nach aussen wiefolgt:
(a) Berechnen Sie die Divergenz von $\vec{v}$ :

$$
\operatorname{div} \vec{v}=1+8^{\star} y+4^{\star} z
$$

(b) Berechnen Sie das Volumenintegral:

$$
\iiint_{W} \operatorname{div} \vec{v} \mathrm{~d} V=7
$$

(c) Berechnen Sie den Fluss von $\vec{v}$ durch die in $S$ fehlende Würfelseite $F$ (also wo $z=0$ ) von $W$ weg:

$$
\iint_{F} \vec{v} \cdot \vec{n} \mathrm{~d} O=-5 / 3
$$

(d) Kombinieren Sie die Resultate aus (b) und (c) und schliessen Sie:

$$
\iint_{S} \vec{v} \cdot \vec{n} \mathrm{~d} O=16 / 3
$$

## Some results II－Participation

－Participation rate
$\simeq$－Success rate

## Some results II－Some problems were hard！



〒 Tries／student
——Tries／success

## Future goals

Through ETH's teaching innovation funds, we hired a developer for this project

Meike Akveld, akveld@math.ethz.cl Andreas Steiger, asteiger@math.ethz. (Hi George!)

- Create more STACK questions as practice material and set up a database for our department
- Design comprehensive training modules (e.g. integral trainer)
- Use STACK in online or computer based exams
- Extend to other areas in mathematics (e.g. linear algebra or proofs)
- Get other departments interested in STACK (we will present STACK next week at the ETH's Innovation in Learning and Teaching Fair 2022)



## Thank you for your attention!

