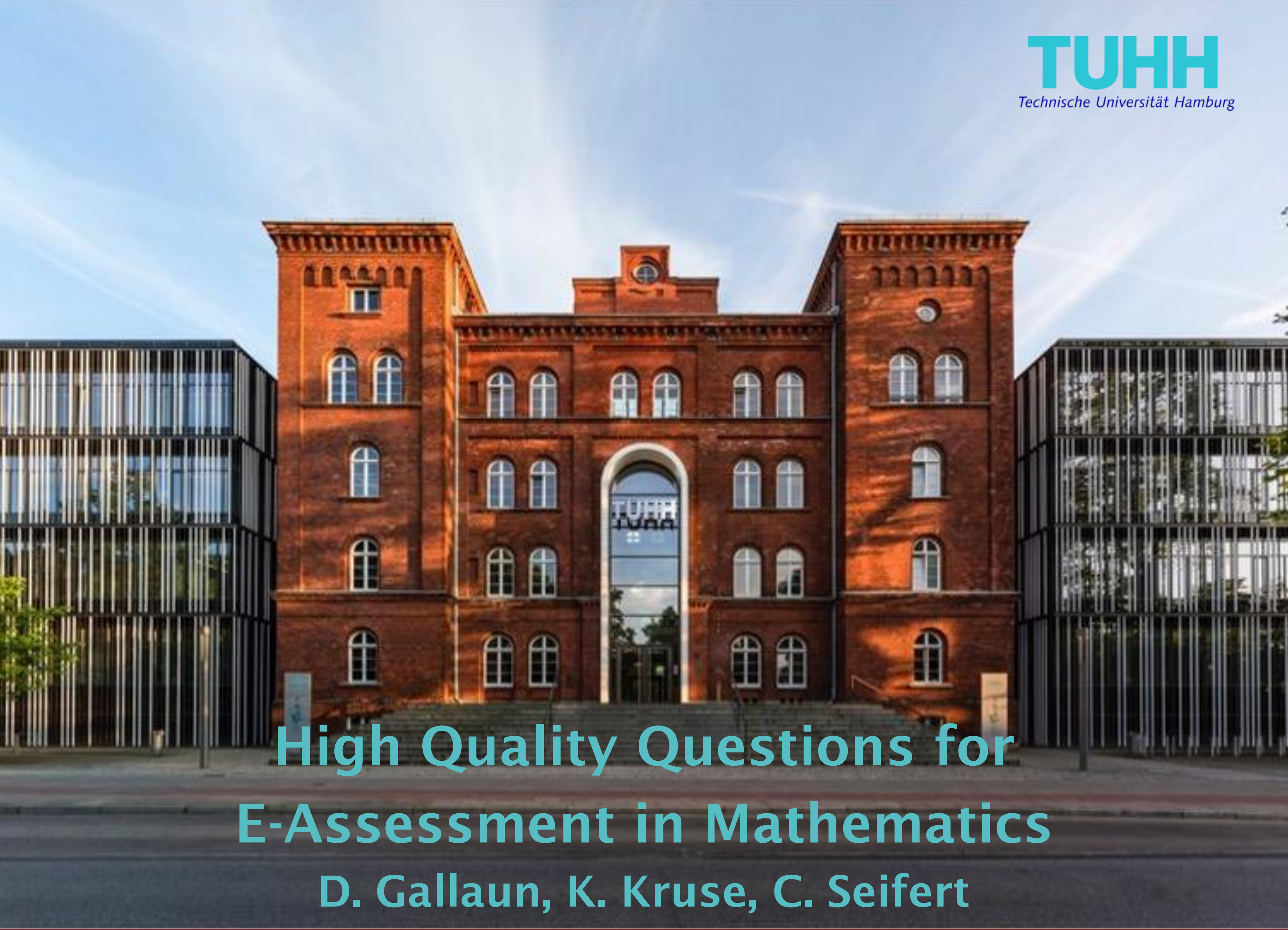

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High Quality Questions for E-Assessment in Mathematics

D. Gallaun, K. Kruse, C. Seifert

Outline

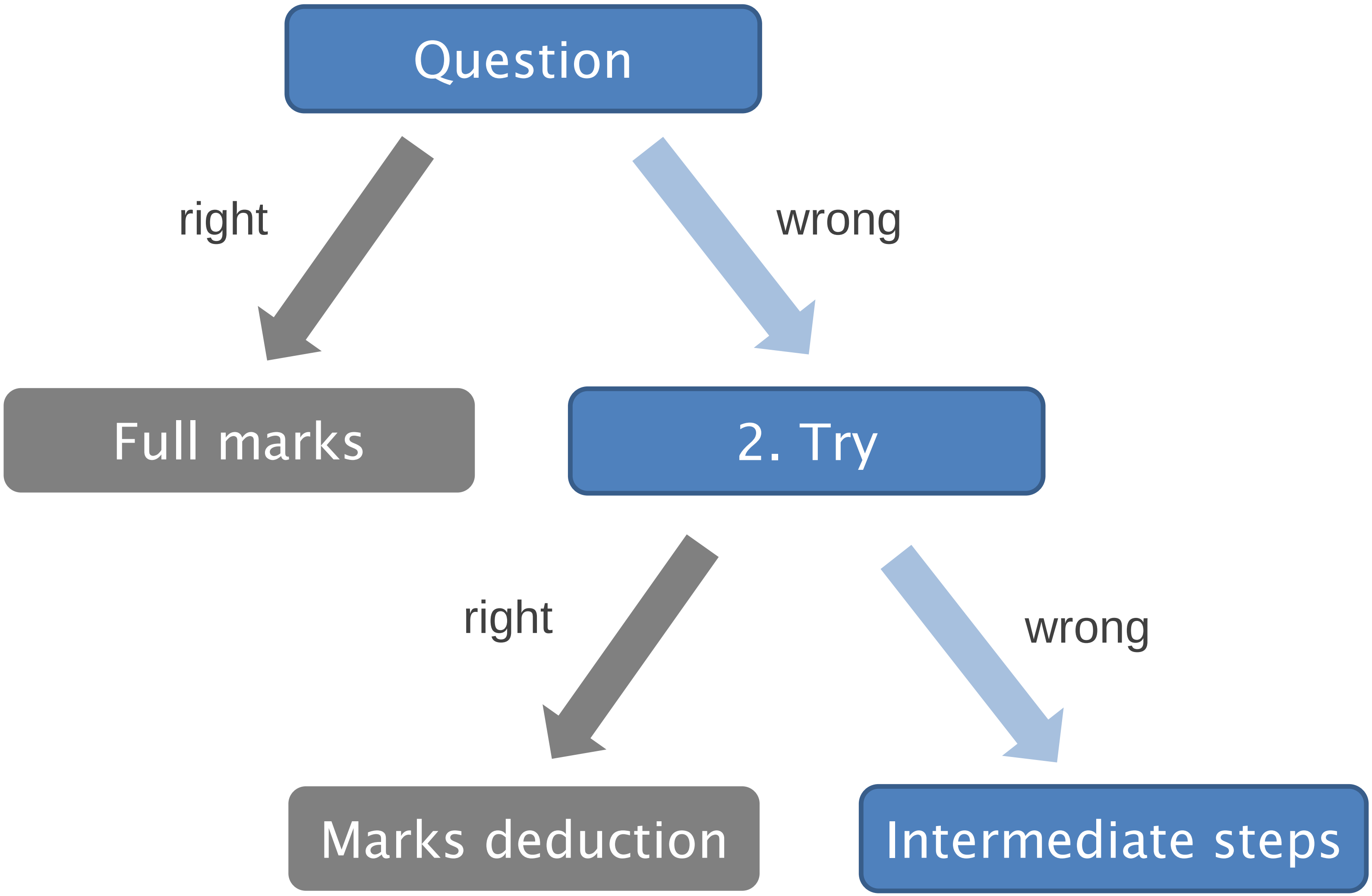
Adaptive Questions

Randomisation

Proof Puzzles

Survey Results

Adaptive Questions



Adaptive Computational Tasks

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- Intermediate steps according to a classical solution
- Sample solutions after every intermediate step
- Handling of follow-up errors

Determine the set of solutions in $\mathbb{R}^3$ *of the system of linear equations*

$$\begin{pmatrix} 2 & 2 & 2 \\ 2 & 3 & 1 \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}.$$

Bring the system of linear equations in a row echelon form.

A row echelon form of the system of linear equations is

$$\left(\begin{array}{ccc|c} 2 & 2 & 2 & 0 \\ 0 & 1 & -1 & 0 \end{array}\right).$$

Determine the free variables.

By passing the variable x_3 *to the right-hand side, we get the system of linear equations:*

$$\begin{pmatrix} 2 & 2 \\ 0 & -1 \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} = \begin{pmatrix} -2x_3 \\ x_3 \end{pmatrix}.$$

Determine the set of solutions depending on the variable x_3.

Pros	Cons
Efficiently check follow-up errors	Fixed solution path
Fair & transparent assessment	Enter intermediate results
Higher learning success	Higher creation effort

Randomisation

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- Individual tasks make fraud attempts more difficult
- Challenge: comparable level of difficulty
- Appropriate assessment schemes/algorithms needed

Randomisation via Reverse Engineering:

Determine the set of solutions in $\mathbb{R}^3$ *of the system of linear equations*

$$\begin{pmatrix} 2 & 2 & 2 \\ 2 & 3 & 1 \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}.$$

- Choose the entries of the LU decomposition randomly:

$$\begin{pmatrix} 2 & 2 & 2 \\ 2 & 3 & 1 \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ \mathbf{1} & 1 \end{pmatrix} \begin{pmatrix} \mathbf{2} & \mathbf{2} & \mathbf{2} \\ 0 & \mathbf{1} & \mathbf{-1} \end{pmatrix}$$

- Control over the complexity of the calculation steps

Proof Puzzles

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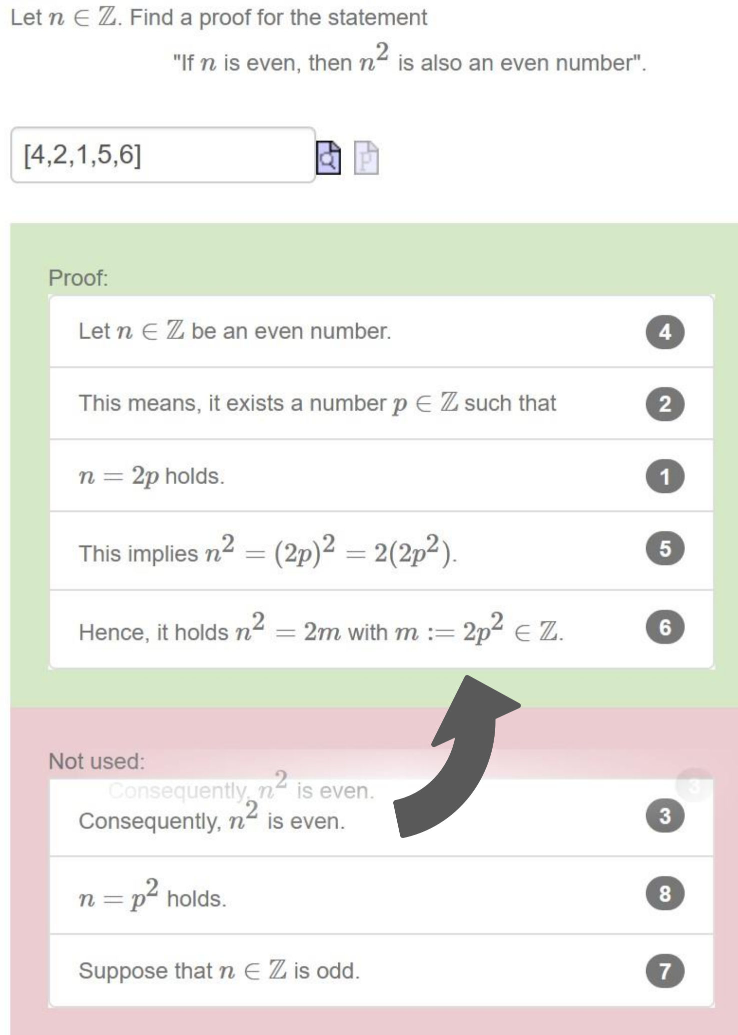
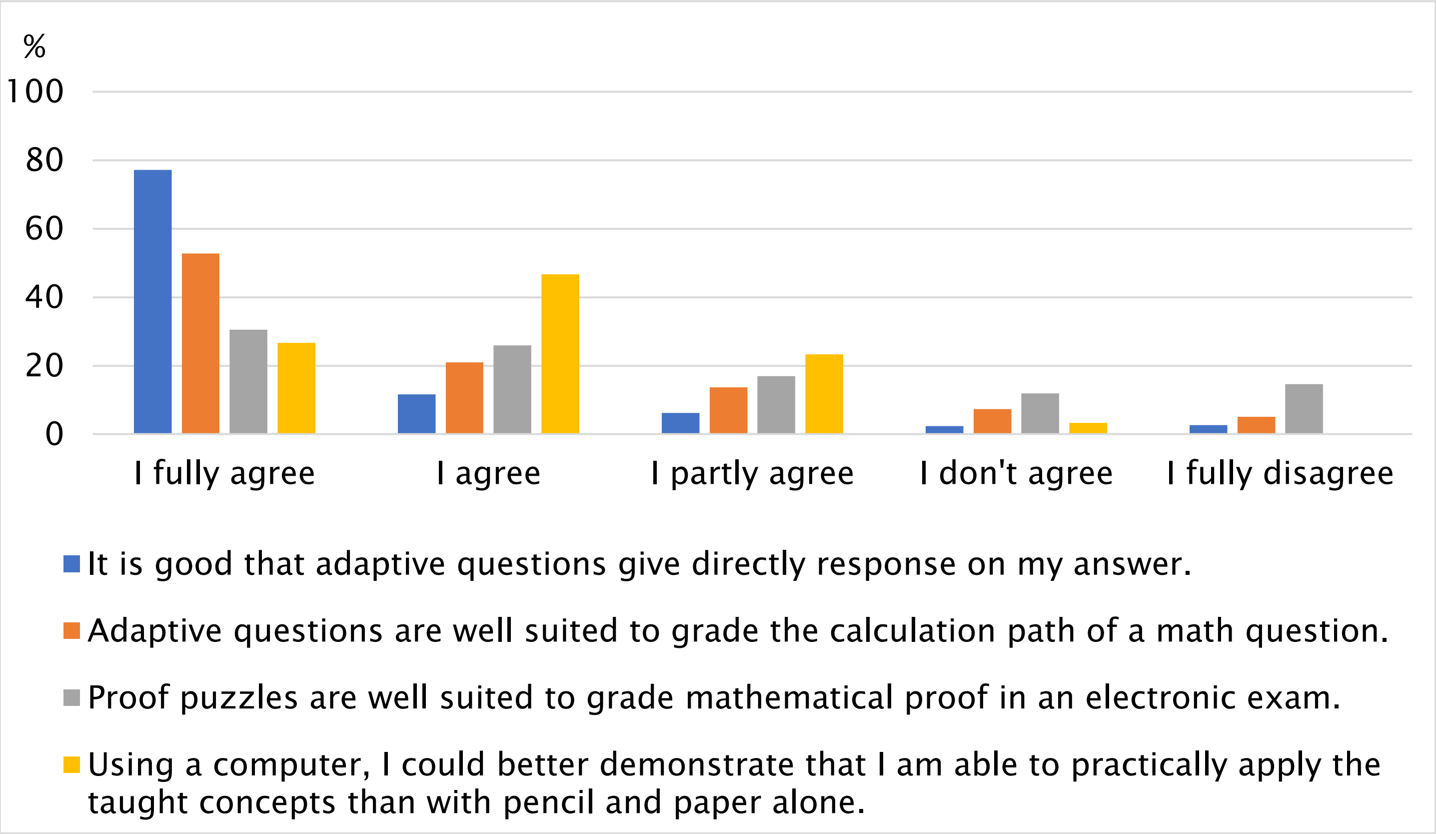
- Assess proofs electronically
- Sort via drag‘n‘drop
- Grading algorithm
  - Edit distance
  - Works even with several sample solutions

Pros	Cons
Quite intuitive input	Fixed structure
Automatic grading	Only short proofs
Assess logical reasoning	Sentence structure exploitable



Survey Results



Results of surveys conducted in the courses Mathematics for engineers (questions 1-3, N=415) and Stochastics (question 4, N=41).

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Thank you for your attention!