Using eLearning to support students in achieving their learning outcomes and competences

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Outline

- **Focus Group:**
  Mathematics education in traditional engineering and sciences disciplines
- **Challenge:**
  Exceptional mathematical *and* computational skills required
- **Solution:**
  Substantial collection of eLearning examples and challenging scenarios

Three-level-system: Basics – Focus – Linking

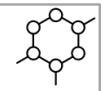
1: Basics

- Requirements
- Previous education
- Repetition of skills (in later chapters)

2: Focus

- Main part of learning outcomes
- Consolidate skills
- Reflect capabilities

3: Linking



- Bringing concepts together
- Repetition and deepening

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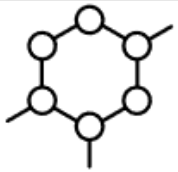

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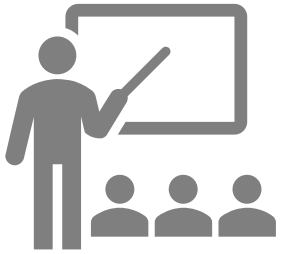


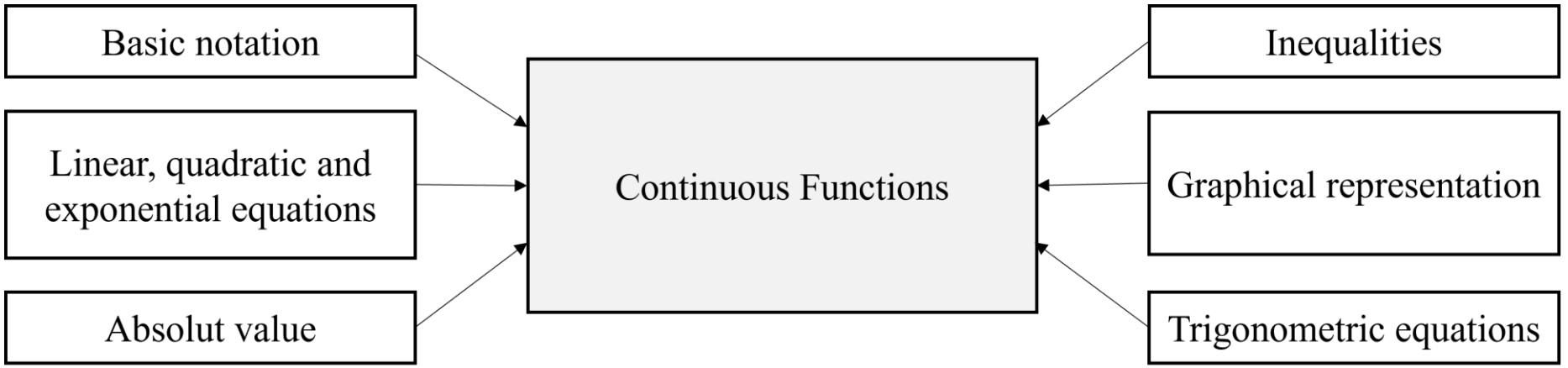
Modiz, Körner: An innovative, technology-enhanced instructional approach to address the diverse competencies of STEM students in math classes. 9th International Conference on Higher Education Advances (HEAd'23), Valéncia, 2023

Level 1 – Basics

- Based on secondary school mathematics
- Mandatory set of exercises covering the chapter

1: Basics

- Requirements
- Previous education
- Repetition of skills (in later chapters)



Level 2 – Focus

- Addresses the learning outcomes to be achieved
- Contains mainly examples of the “traditional” course type
- Students must submit at least 60% of the examples in total
- Presented weekly in exercise courses

2: Focus

- Main part of learning outcomes
- Consolidate skills
- Reflect capabilities

Consider the function $f(x) = \frac{-5x^3+15x^2-20x-10}{(x-2)^2\left(x^2+2\right)}$.

Calculate the antiderivative F of f.

$F(x) =$ $+c,\ c \in \mathbb{R}$

Hint: If necessary, include modulus within the argument of the logarithmic function.

Grade | How Did I Do? | Refresh | Close

Level 3 – Linking

3: Linking

- Bringing concepts together
- Repetition and deepening

- Facilitates the linking of knowledge and skills of the different chapters
- Oriented towards the final exam of the course in the end of the semester
- Not mandatory, but bonus points awarded
- Discussed with a tutor on fixed dates during the semester

Variations of the 3-level concept

- Combined lecture and exercise courses without a summative final exam
- Adjustment of mandatory requirements according to shorter (blocked) courses
- Prerequisites from other courses of the same or previous semester
- Coordination of subjects (math and applications) in the same semester

Automatic Assessment Systems (AAS)

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Immediate Interactive Feedback for Students

Constant Availability

Multitude of Mathematical Tasks through Randomization

Automated Grading of Mathematical Expressions

Maple™

möbius

Grading beyond Algebraic Expressions

How can we **effectively** overcome the limitations of grading other forms of expressions?

By compiling the self-developed grading code functions into a form of a **Library**

Grading beyond Algebraic Expressions

Library – Design Choices to Consider

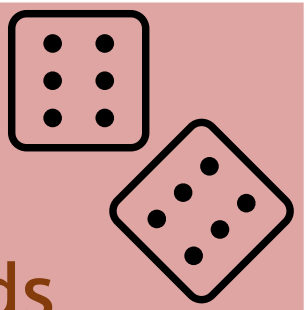
- Redefining the default scoring options – optional **Partial Credit** grading
- Defining the set of allowed commands
- Adapting library for custom syntax
- Extending the concept to other domains of task design

Winkler, Körner, et al.: Maple T.A. in Engineering Educations. IFAC Proceedings Volumes, **45(2)** (2012).
Zimmermann, Körner, et al.: Randomisation and Grading of Complex Questions in the E-Learning System Maple T.A. SNE, 21(2) (2011)

Randomization

... leads to

- greater variety of learning material for students
- conceptual understanding of calculation methods
- reusability of tasks for consecutive examination dates



Randomization - Example

Goal

Design a task that requires the student
to calculate the determinant of a given matrix.

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```
# Generate an integer between 2 and 5
$r = range(2,5);

# Generate ($rx$r)-matrix with values between -4 and 4
$A = maple("LinearAlgebra[RandomMatrix]($r, $r, generator = -4..4)");
```

Randomization - Example

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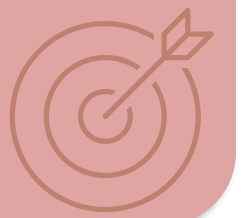

Consider a matrix $A \in \mathbb{R}^{3\times 3}$ given as

$$A = \begin{pmatrix} -3 & -2 & 2 \\ 1 & -2 & -3 \\ 4 & 4 & 2 \end{pmatrix}.$$

Caluculate the determinant of A.

$\det A =$ [ ]

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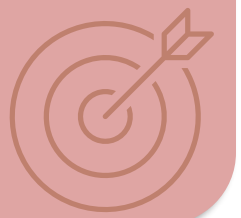

Consider a matrix $A \in \mathbb{R}^{5\times 5}$ given as

$$A = \begin{pmatrix} 3 & 0 & 2 & 0 & -3 \\ -2 & 4 & 4 & 2 & -4 \\ -3 & 2 & -3 & 3 & -4 \\ 1 & -4 & -1 & -2 & -4 \\ 4 & -4 & -1 & 1 & 3 \end{pmatrix}.$$

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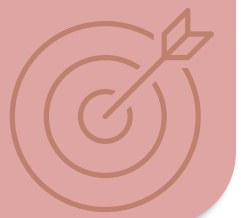

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Library Overview

Grading

Predefined and tested code leads to a uniform evaluation and greater flexibility

Randomization

Restrictions to predefined randomization commands

Print

Uniform display of mathematical expression
Costum syntax recommended

Computation

Call long arithmetic operations simplified as commands

Task Differentiation

Exercise Tasks

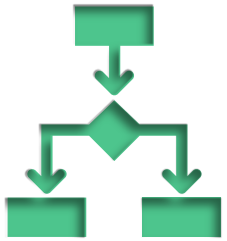
- Learning Material
- Adaptive Questions
- Greater Flexibility Regarding Randomization

Exam Tasks

- Caution with Randomization
- Comparability
- Preventation of Cheating
- Reusability of Questions

Take away message

Customization of AAS



Task Differentiation

Code Library

Summary

- Defined learning outcomes (LE)
- Didactic adapted teaching system to reach LE
- Good proportion of in person teaching and independently learning
- Use of eLearning tools of a sufficient quality
- A lot of feedback to the students
- Courses inherent in the examination instead of hard final exams

Thank You For Your Attention!

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Q&A