Maths - practise digitally - examine digitally

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HAW HAMBURG

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Faculty of Engineering and Computer Sciences

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E-Assessment
Digital Exercises and Digital Exams

CONTENT

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(1) Introduction

(2) Digital Exercises and Exams - Possibilities and Requirements

(3) Semester-accompanying Digital Exam in Mathematics

(4) Outlook

INTRODUCTION

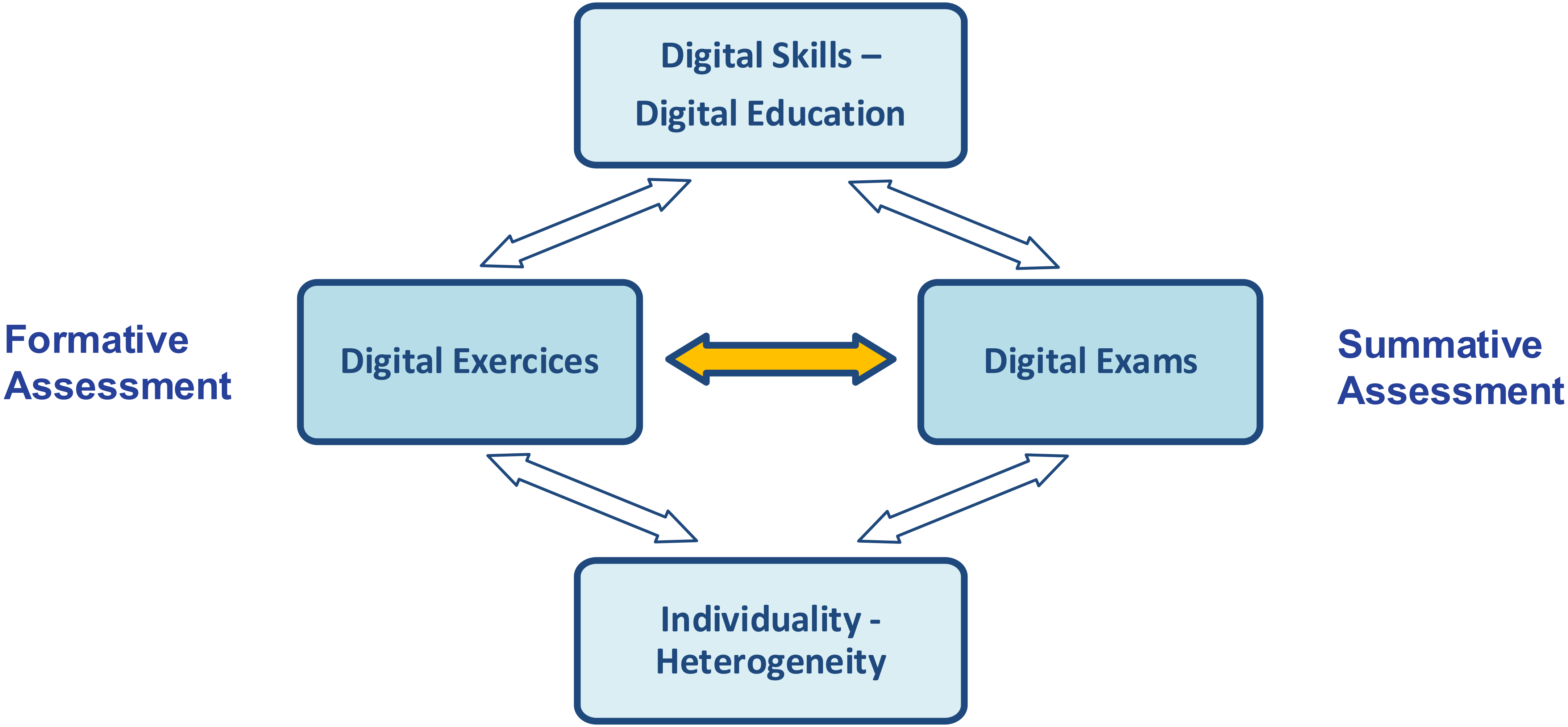
Learning with digital exercises

- … is a helpful supplement for maths courses
- …supports the students learning and understanding process
- ...enables students to learn individually
- ...independent of location and time
- ...with a self-determined number of tasks and repetitions
- ... should be fun and motivate learning
- …should be considered helpful by the students
- ...requires tasks that fulfil helpful and necessary characteristics

Exam with digital tasks

- … is a suitable connection to learning with digital exercises
- … requires examination tasks with which the acquired knowledge and competences can be tested.
- ... enables new examination scenarios that are beneficial for students and teachers alike, which need to be discovered and developed.

INTRODUCTION



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DIGITAL EXERCISES – POSSIBILITIES AND REQUIREMENTS

Properties and Requirements for the task system and tasks depending on the application scenario

- Different task types for different levels of difficulty and competencies
- Automated checking/assessment of tasks
- Recognition of the error, including subsequent errors and misconceptions
- Differentiated individual feedback
- Individualisation of tasks for exams
- Repeated workability of similar tasks
- Provision of a suitable worked-out sample solution for learning and understanding
- Consideration of subject-specific characteristics: math. formulas, source code, chem. formulas...
- Integration of interactive visualisations

DIGITAL EXERCISES – POSSIBILITIES AND REQUIREMENTS

Realisation of digital mathematics tasks with Moodle/STACK/Maxima/JSXGraph

- Enables many different types of tasks
- Mathematical formula input - with preview
- Syntax input help
- Verification of mathematical equivalence via connected CAS Maxima
- Individualisation of tasks with randomised elements (e.g. randomisation of parameters, selection from a question pool)
- Feedback based on an implemented answer tree
- Follow-up error check can be implemented
- Graphical input and verifiability via Geogebra and JSXGraph

Example of a not very helpful digital task for learning and exams

The following ODE is given:

$$2y'' - 8y' + 6y = \sin(x)$$

Enter the general solution of the non-homogeneous ODE:

$y(x) =$ [ ]

Please note: Enter the specific solution function!

- many calculations, few input fields
- time-consuming
- only few feedback options
- no options for partial scoring

DIGITAL TASKS – THREE EXAMPLES

Solving the task according to a predefined path

The following ODE is given:

$$2y'' - 8y' + 6y = \sin(x)$$

(1) First find the solutions to the characteristic equation:

$\lambda_1 =$ ___ , $\lambda_2 =$ ___

(2) What are the linearly independent solutions of the fu

$y_1(x) =$ ___

$y_2(x) =$ ___

(3) Find the general solution to the homogenous ODE. U

$y_h(x) =$ ___

(4) Find a particular solution of the non-homogeneous O

Use the ansatz: $y_p(x) = a \cdot \sin(x) + b \cdot \cos(x)$

$y_p(x) =$ ___

(5) Enter the general solution of the non-homogeneous

$y(x) =$ ___

Please note: Enter the specific solution function!

„Inverse“ question: Conclusion from the solution to the task

Question is missing tests or v

The fundamental solutions of a linear, homogeneous second order differential equation with constant coefficien are given:

$$y_1(x) = \cos(3 \cdot x)$$

$$y_2(x) = \sin(3 \cdot x)$$

1. Which solutions of the characteristic equation can you deduct from the fundamental solutions?

$\lambda_1 =$ ___ , $\lambda_2 =$ ___

2. What is the specific characteristic equation for this differential equation

Please note: Enter λ as `lambda`.

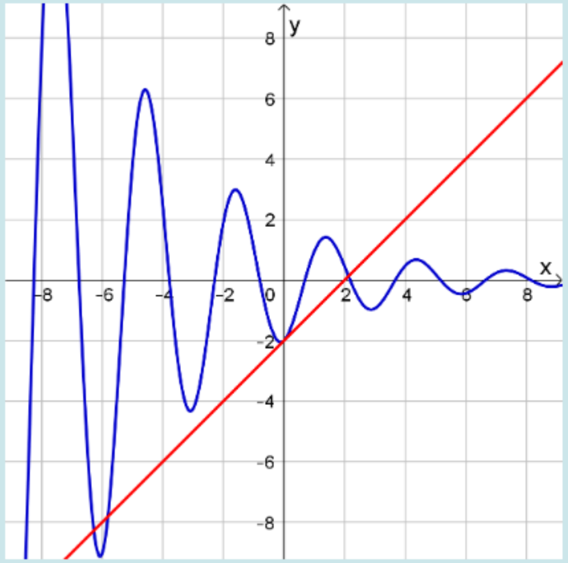
___ $= 0$

3. Please enter the corresponding differential equation. Fill in the gaps.

$y'' +$ ___ $y' +$ ___ $y =$ ___

Question with graphic understanding and only a little calculation

linear homogeneous differential equation with constant coefficients (blue curve)



a) Which properties of the roots of the characteristic equation can you deduce from the diagram (blue curve)?

- ○ The roots are complex with positive real part.
- ○ There is only one real double root.
- ○ The roots are complex with negative real part.
- ○ The roots are real and distinct.
- ○ It is not possible to make a statement about the roots.

b) Use the diagram (red tangent) to determine the initial conditions that gave rise to this solution:

$y(0) =$ ___

$y'(0) =$ ___

DIGITAL EXERCISES - EXAMPLE

The following ODE is given:

$$2y'' - 8y' + 6y = \sin(x)$$

(1) First find the solutions to the characteristic equation:

$\lambda_1 =$ [ ], $\lambda_2 =$ [ ]

(2) What are the linearly independent solutions of the fundamental system?

$y_1(x) =$ [ ]

$y_2(x) =$ [ ]

(3) Find the general solution to the homogenous ODE. Use C and D to denote the consta

$y_h(x) =$ [ ]

(4) Find a particular solution of the non-homogeneous ODE.

Use the ansatz: $y_p(x) = a \cdot \sin(x) + b \cdot \cos(x)$

$y_p(x) =$ [ ]

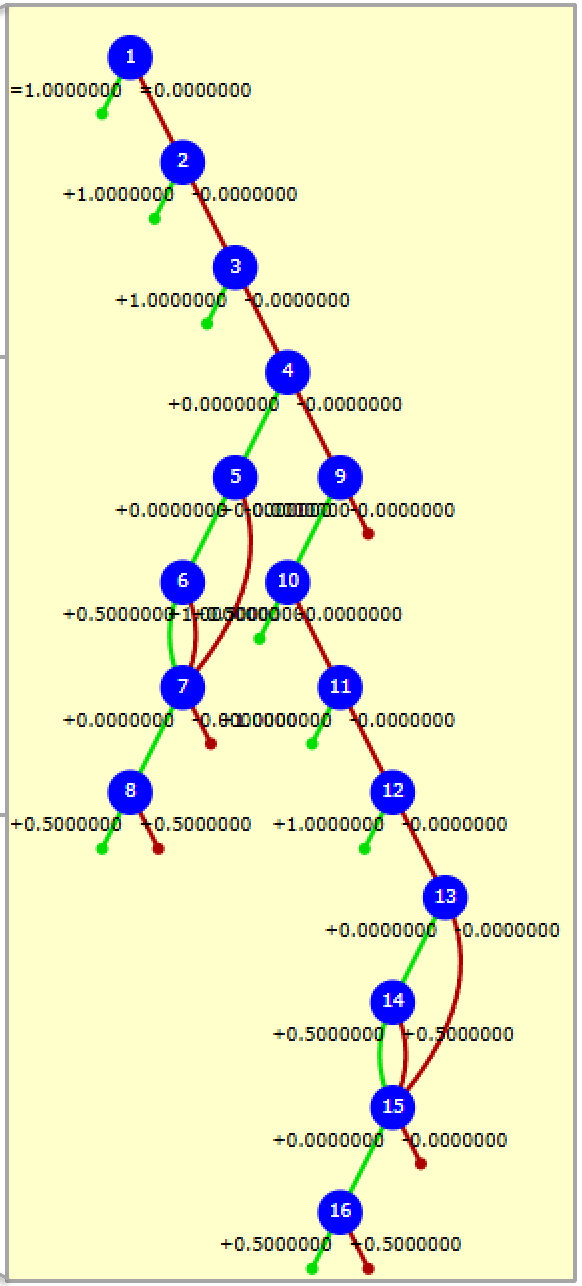
(5) Enter the general solution of the non-homogeneous ODE:

$y(x) =$ [ ]

Please note: Enter the specific solution function!

Response tree for input fields 3 and 4

- taking into account the values of input fields 1 and 2
- recognising follow-up errors and awarding partial points



DIGITAL EXERCISES - EXAMPLE

The fundamental solutions of a linear, homogeneous second order differential equation with constant coefficients are given:

$$y_1(x) = \cos(3 \cdot x)$$

$$y_2(x) = \sin(3 \cdot x)$$

1. Which solutions of the characteristic equation can you deduct from the fundamental solutions?

$\lambda_1 =$ -3j , $\lambda_2 =$ +3j

Correct answer, wel

Both roots are correct.

2. What is the specific characteristic equation for this differential equation?

Please note: Enter λ as `lambda`.

lambda^2-9 $= 0$

Your last answer was interpreted as follows:

$$\lambda^2 - 9$$

Your answer is parti

There is a sign error in yo

3. Please enter the corresponding differential equation. Fill in the gaps.

$y'' +$ 9 $y' +$ 0 $y =$ 0

Your answer is parti

The term $9y'$ is wrong.

The term $0y$ is wrong.

The right-hand side of the ODE is correct.

Implemented feedback texts for the third input field, depending on the input made:

- The characteristic equation is correct.
- Consequential error: With your (incorrect) values for λ_1, λ_2, the characteristic equation is correct.
- There is a sign error in your characteristic equation.
- Consequential error: With your (incorrect) values for λ_1, λ_2, the characteristic equation is correct except for a sign error.
- The characteristic equation is not correct.
- The characteristic equation does not match your specified values for λ_1, λ_2.

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SEMESTER-ACCOMPANYING DIGITAL EXAM IN MATHEMATICS

Objectives:

- To motivate students to study during the semester
- To take the pressure off the examination phase at the end of the semester.
- As a teacher, to monitor the learning progress of students

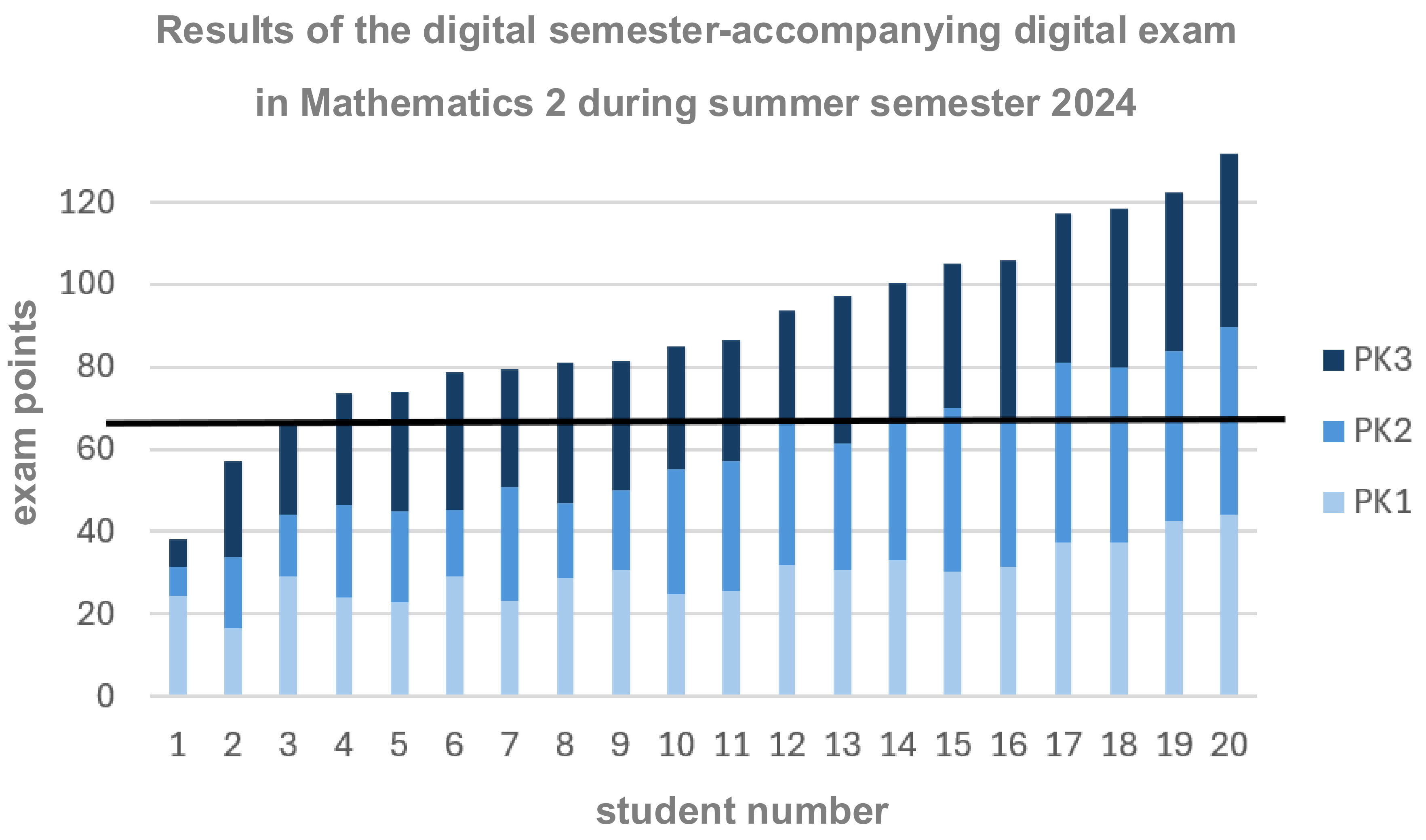
Realisation:

- Provision of weekly digital exercises to match the lecture
- Three partial examinations equally distributed during the semester.

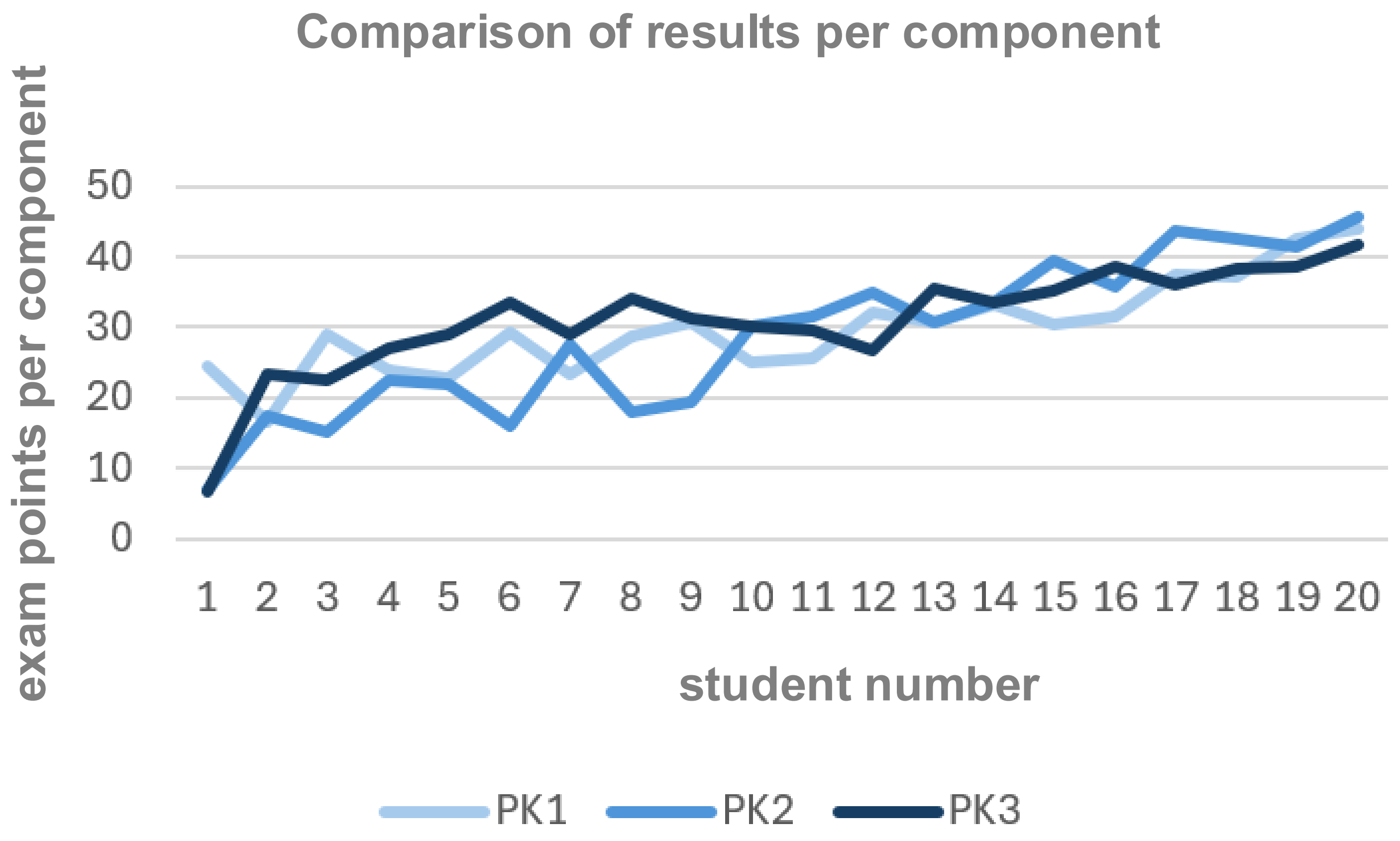
SEMESTER-ACCOMPANYING DIGITAL EXAM IN MATHEMATICS

- **Digital exam with three components during the semester** was conducted in the summer semester 2024 as part of a Mathematics 2 course in the Regenerative Energy Systems and Energy Management degree programme at HAW Hamburg.
- **20 students** took part in the examination with all three components. 2 students only completed the first component.
- The component exams took place **on three dates** during the semester.
- They were carried out **in presence in the PC pools** in a **secured Moodle/STACK-learning environment**.
- One third of the total points for the examination could be collected in each component. The **total score of the examination was 150 points**.
- Due to an overhang of 10%, the maximum number of points for determining the grade was 135 points. **Half of the points (67.5 points) were required to pass the exam**.
- **Special feature:** At the beginning of the semester, students had the choice of 1. taking an examination during the semester or 2. an overall examination at the end of the semester.

SEMESTER-ACCOMPANYING DIGITAL EXAM IN MATHEMATICS



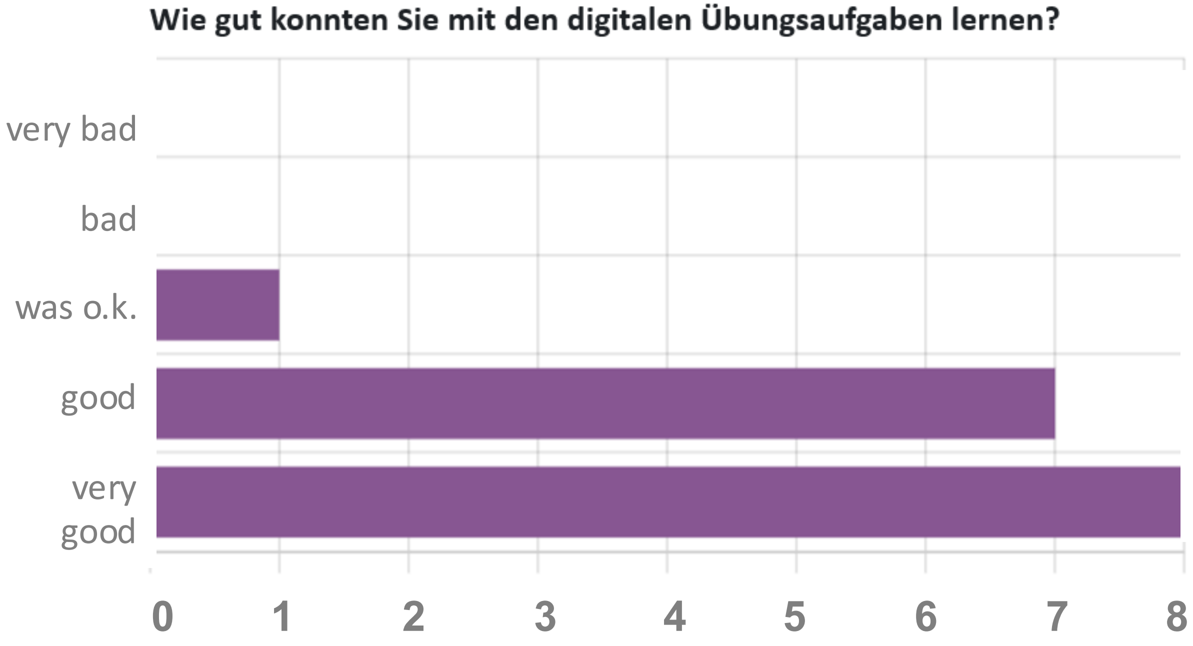
SEMESTER-ACCOMPANYING DIGITAL EXAM IN MATHEMATICS



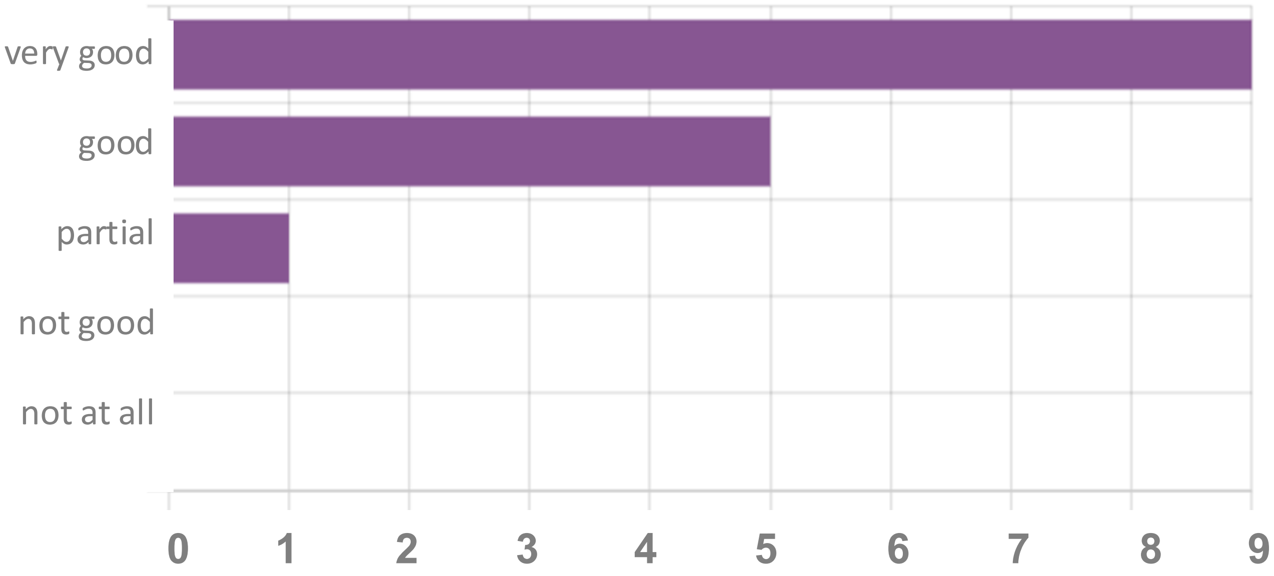
SEMESTER-ACCOMPANYING DIGITAL EXAM IN MATHEMATICS

EVALUATION WITH THE STUDENTS

How well were you able to learn with the digital exercises?



How well fit the tasks in the digital partial exams to test your acquired knowledge?



The students cite three main advantages of a semester-long examination:

1. "the time freed up for other examinations during the examination phase"

2. "the necessary learning during the lecture, so that the maths content can already be used productively in other subjects during the semester."

3. "The opportunity to collect points and know your score early on.

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OUTLOOK

- Development of new examination scenarios to improve studyability
- Expand the use of digital tasks at universities in suitable teaching and learning scenarios
- Cooperation between teachers and universities is importantto advance digital teaching, learning and testing
- Funding for a joint project 'German Centre for Digital Tasks in University Teaching (DZdA) ' with 6 German universities starting on 1 October 2025, duration 6 years - Digital tasks for STEM subjects with Moodle and STACK - development, collection, dissemination (OTH Amberg-Weiden, HTW Berlin, HS Bochum, HAW Hamburg, Universität der Bundeswehr München, TH Würzburg-Schweinfurt)

… TIME FOR QUESTIONS

… TIME FOR DISCUSSION

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SEMESTER-ACCOMPANYING DIGITAL EXAM IN MATHEMATICS