Introduction to Autograding with MATLAB Grader

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Curicculum Vitae

[2003-2009] [2010-2012] [2018-2020] [2021-heute]

[2008-2009] [2012-2018] [2020-heute] t

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University of Munich

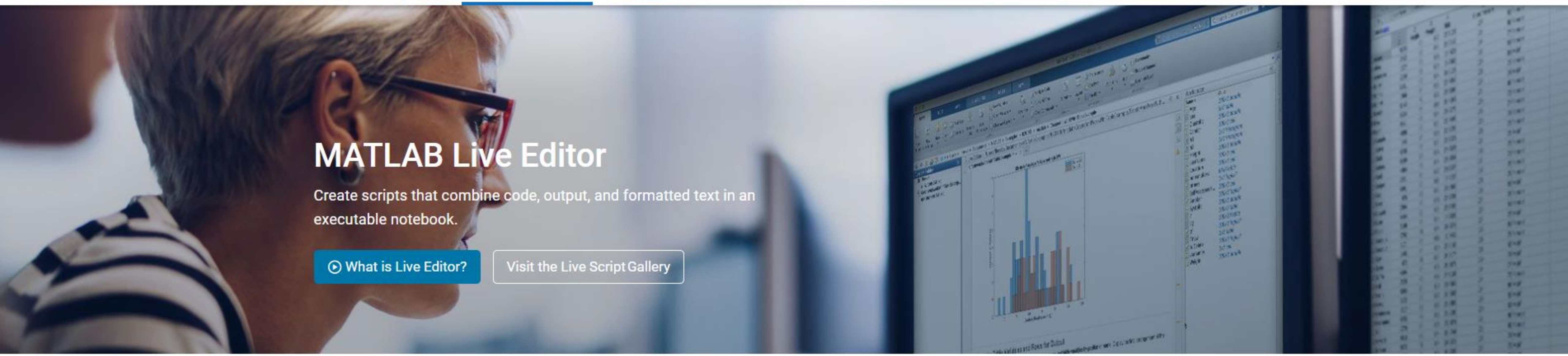
Agenda

- Interactive MATLAB notebooks as teaching materials
  - *Introduction to interactive teaching materials with MATLAB*
  - *MATLAB-based interactive teaching materials in action*
- Flipped classroom concept
  - *Fundamentals of the Flipped Classroom Concept*
  - *Flipped Classroom in Practice*
- Auto-grading with MATLAB Grader
  - *Standard and auto-grading methods*
  - *The Learner- and the Instructor-View of MATLAB Grader*
  - *Integration of MATLAB into OpenOlat via the LTI 1.3 interface*

Interactive MATLAB notebooks as teaching materials

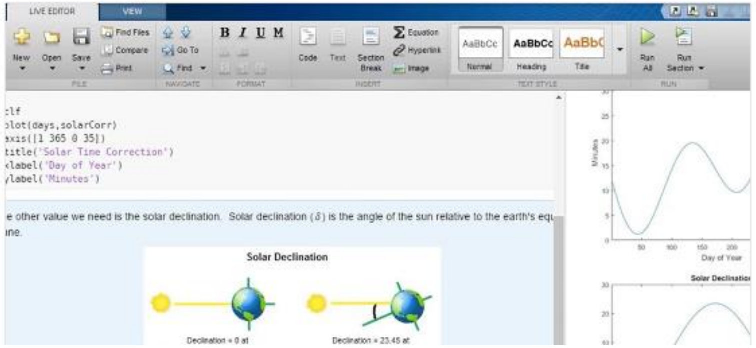
MATLAB

Overview Getting Started Features & Capabilities For Students



Create an Executable Notebook

Create scripts that combine code, output, and formatted text. Divide code into manageable sections that can be run independently. View output and visualizations next to the code that produced them. Enhance your code and results with formatted text, headings, images, and hyperlinks. Insert equations using the interactive editor or create them using LaTeX. Save code, results, and formatted text in a single executable document.



*https://www.mathworks.com/products/matlab/live-script-gallery.html

Introduction to interactive teaching materials with MATLAB

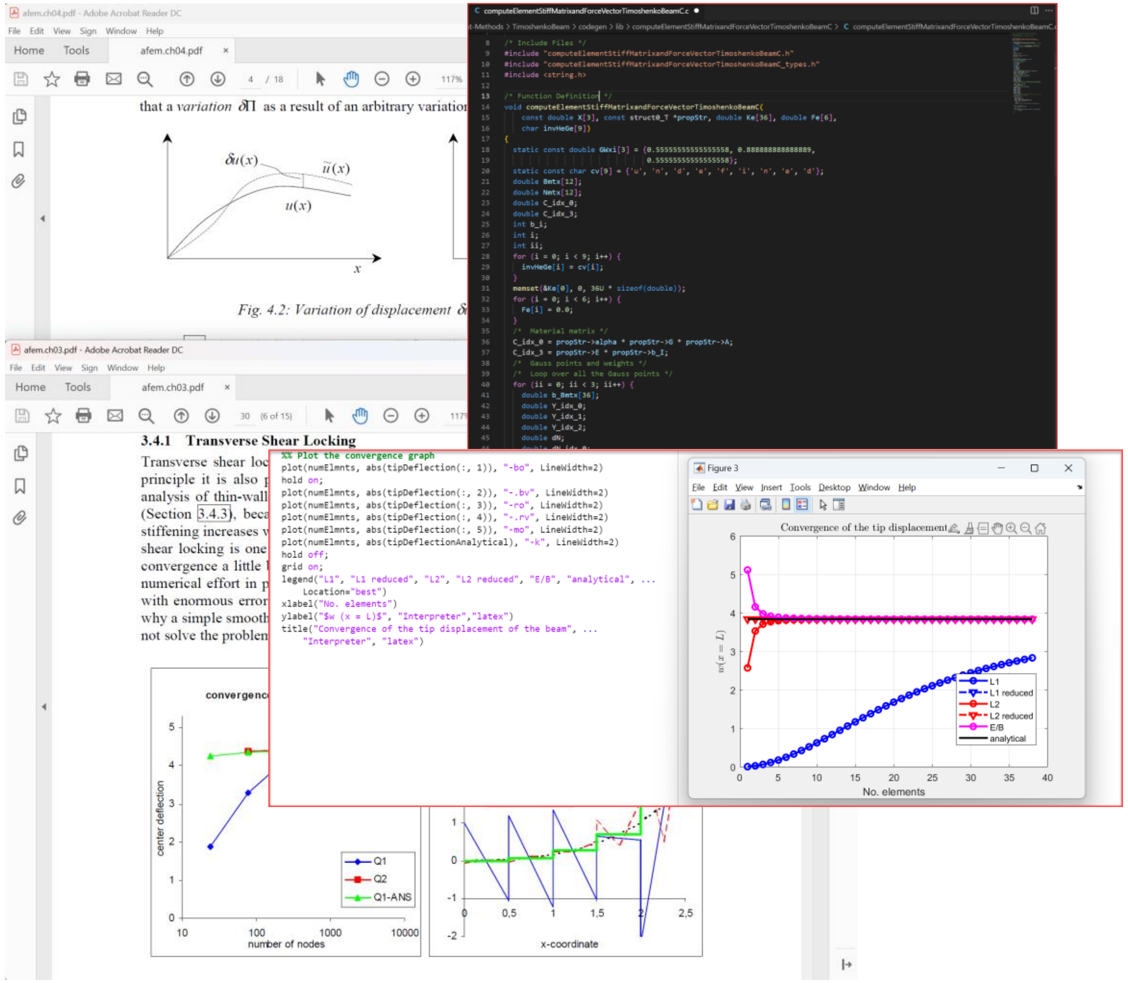


Fig. *Traditional teaching materials*

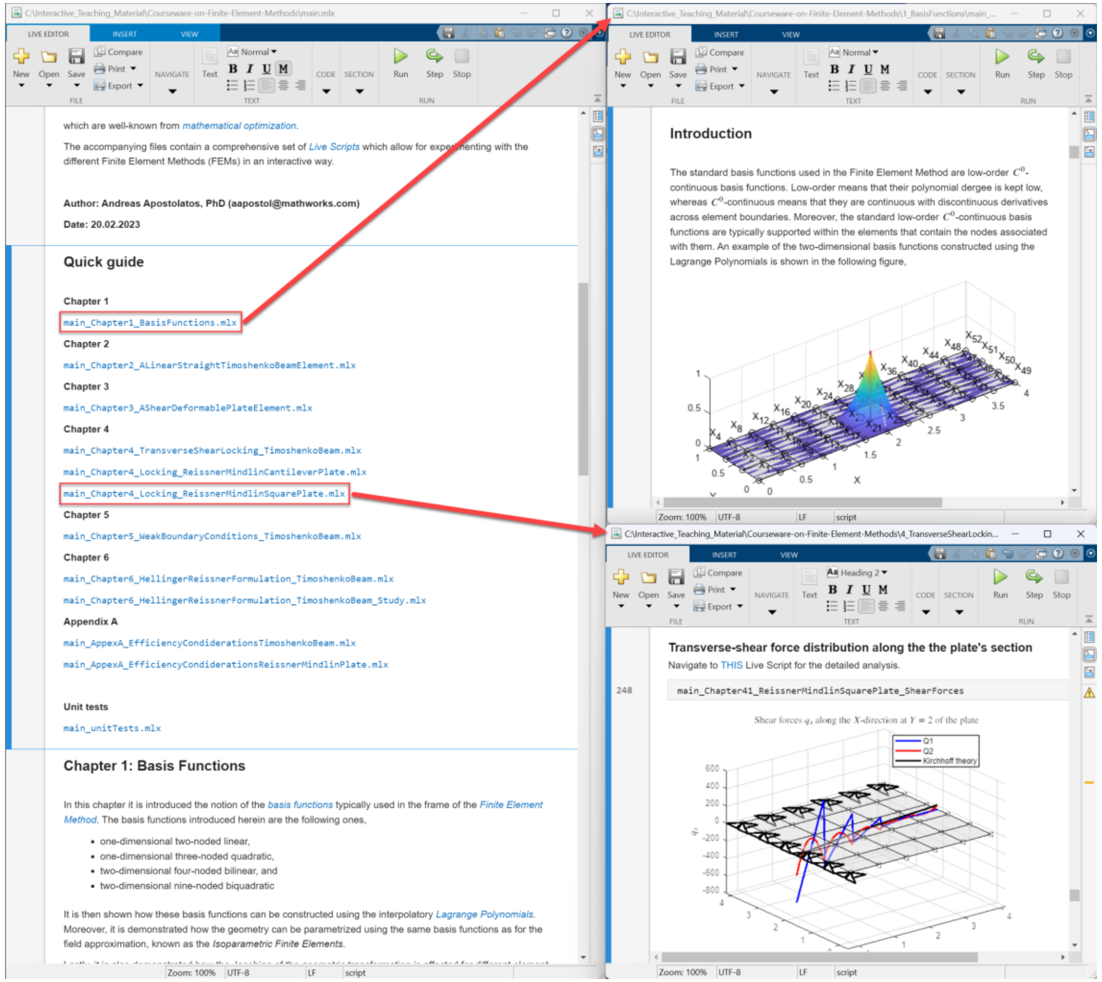
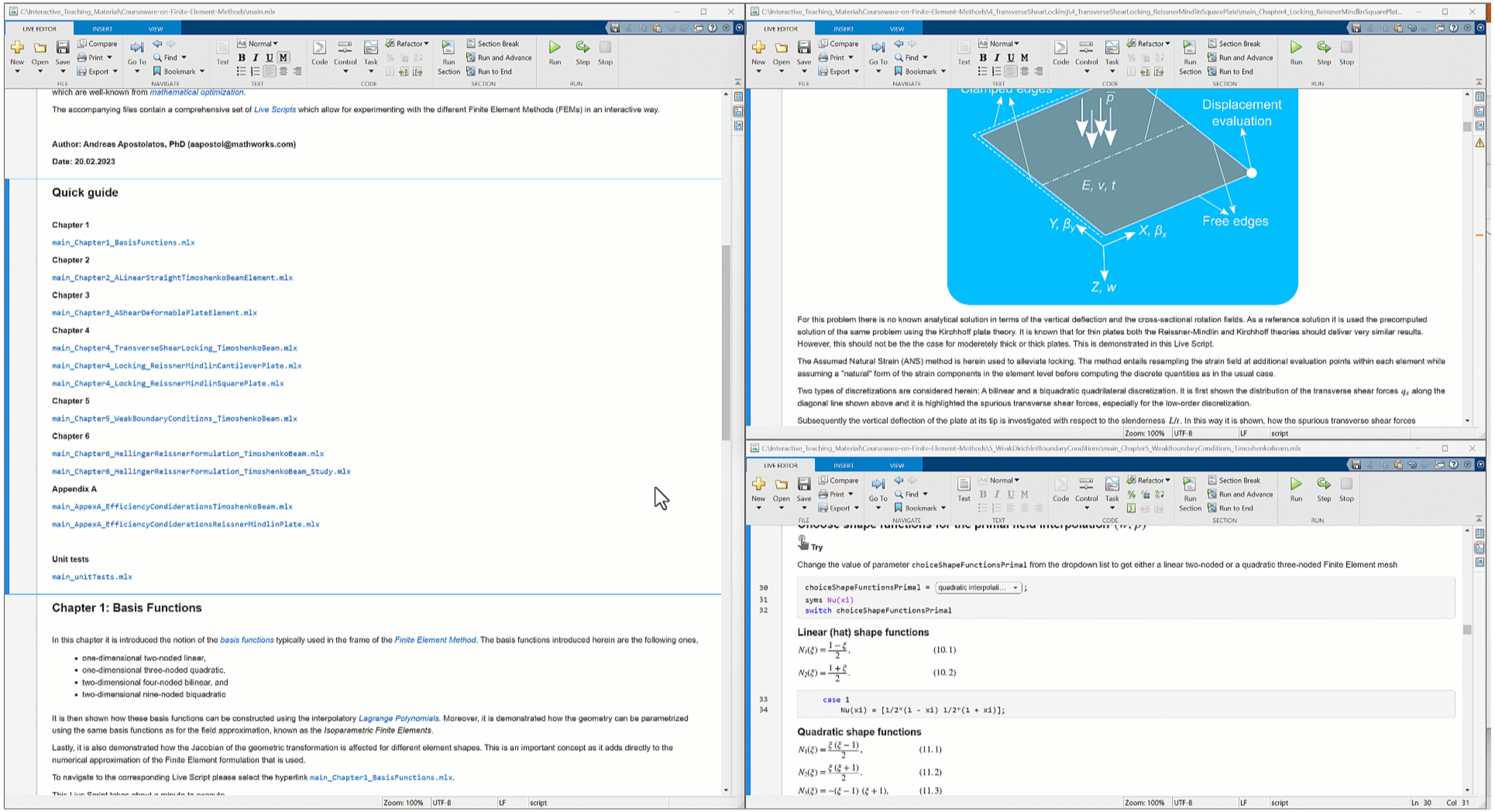


Fig. *Digitized/interactive teaching materials **

**[Apostolatos et al. „Courseware on Finite Element Methods“, MATLAB File Exchange]*

MATLAB-based interactive teaching materials in action

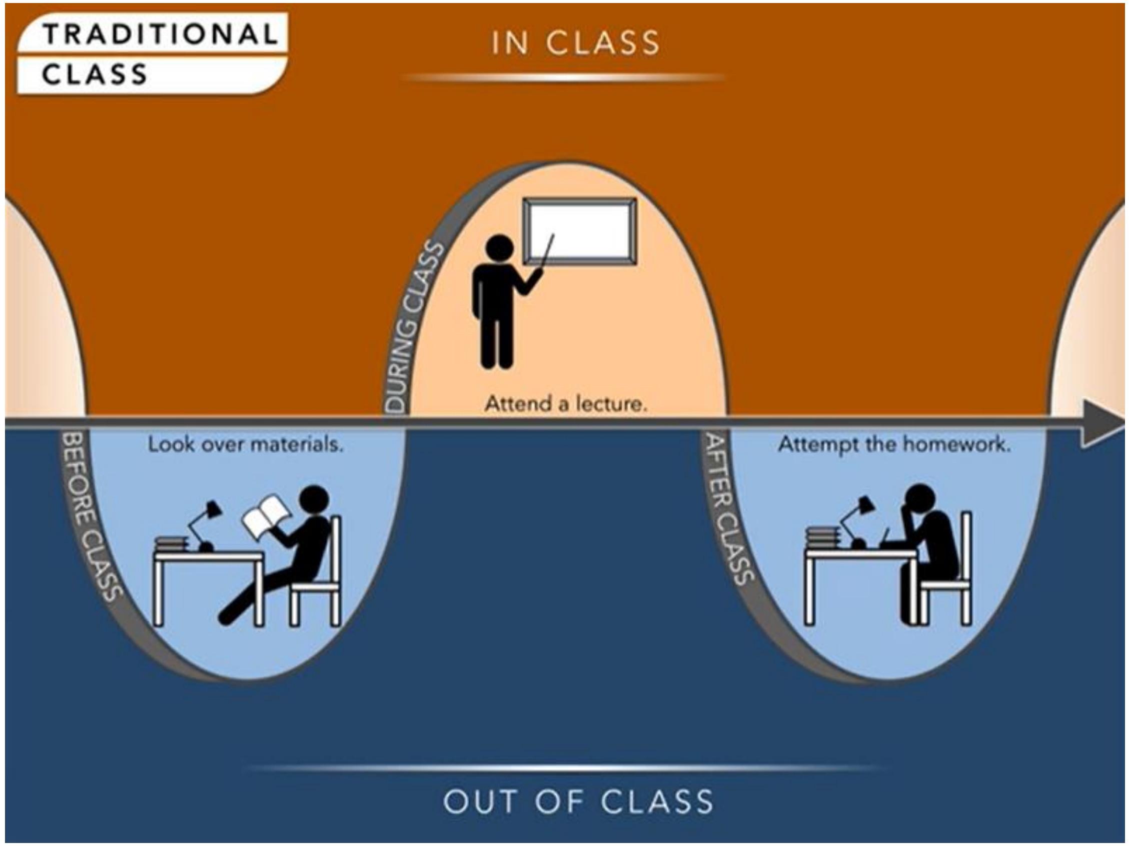


*https://www.mathworks.com/matlabcentral/fileexchange/125135-courseware-on-finite-element-methods

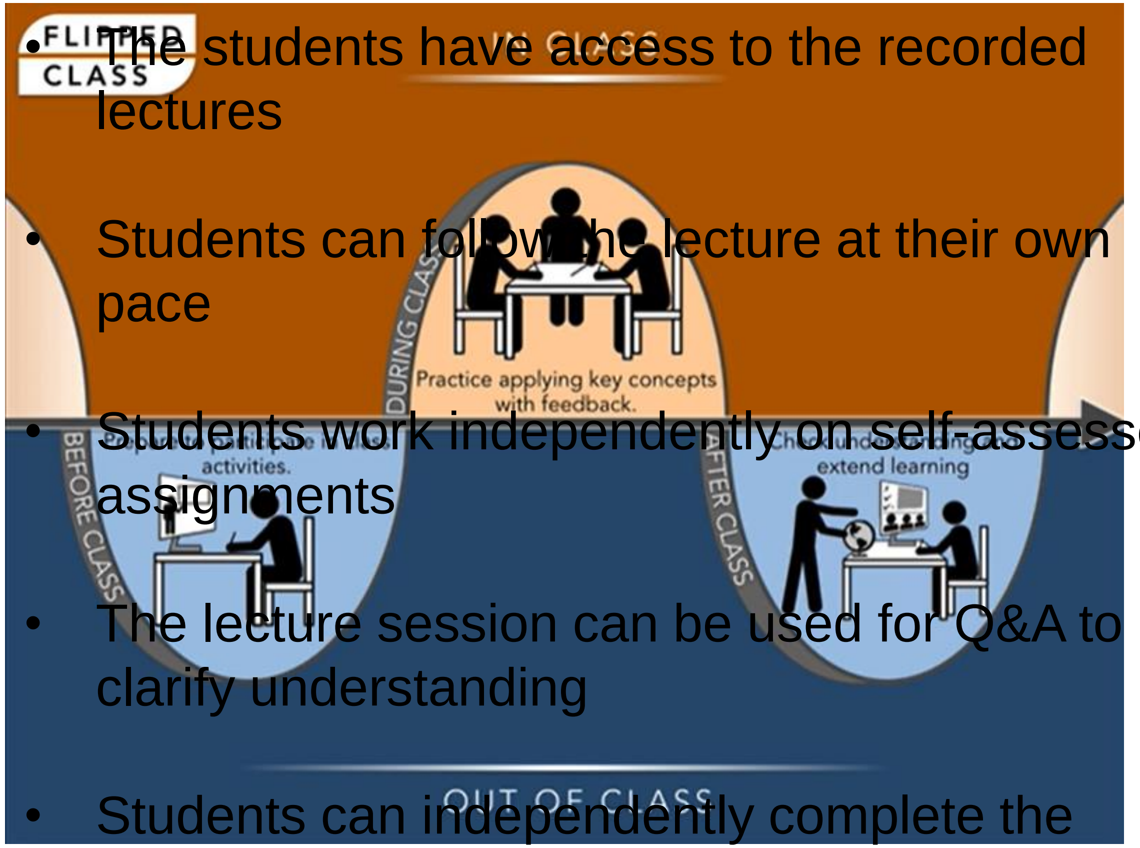
Flipped Classroom

- https://ctl.utexas.edu/instructional-strategies/flipped-classroom

Fundamentals of the Flipped Classroom Concept



Traditional teaching approach



- The students have access to the recorded lectures
- Students can follow the lecture at their own pace
- Students work independently on self-assessed assignments
- The lecture session can be used for Q&A to clarify understanding
- Students can independently complete the remaining tasks

Flipped Classroom

- *https://ctl.utexas.edu/instructional-strategies/flipped-classroom*

Flipped Classroom in Practice

Flipped classroom using digital platforms

- Provision of the chapter's interactive teaching materials
- Access to the chapter’s recorded lecture
- Access to self-graded assignments
- Access to the recorded Q&A (practical) session

Flipped Classroom in Practice

* *Apostolatos, Andreas, Sebastian Gross, and Kai-Uwe Bletzinger. "Teaching the Finite Element Method with Notebooks and Autograded Exercises." 2022 IEEE German Education Conference (GeCon). IEEE, 2022.*

Student Survey on the Effectiveness of Flipped Classroom

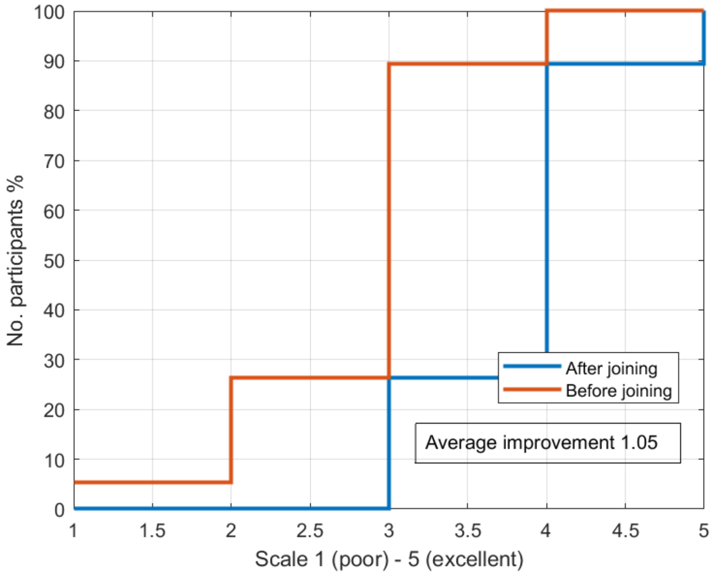


Fig. 2022

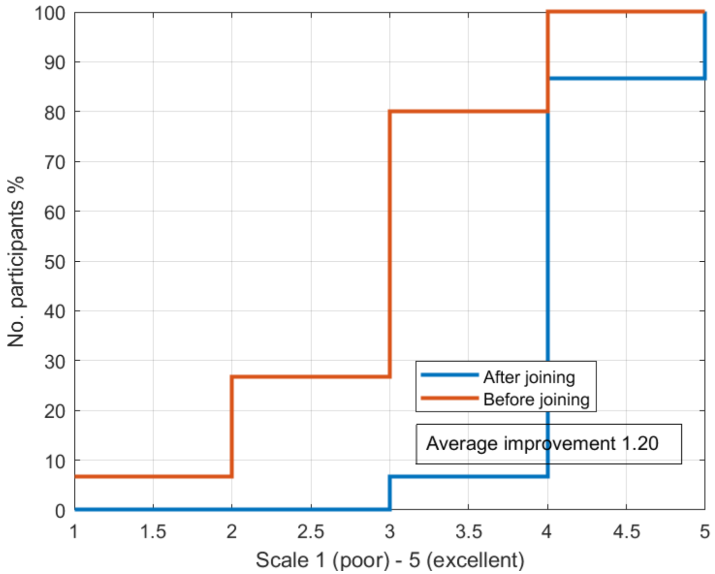


Fig. 2023

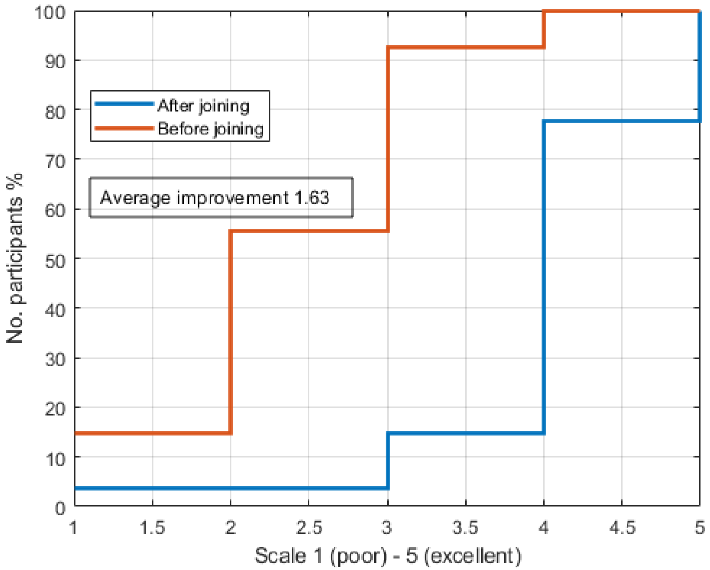


Fig. 2024

*Apostolatos et al. „Teaching the Finite Element Method with Notebooks and Autograded Exercises“, IEEEXplore

Student survey on the effectiveness of the interactive teaching materials

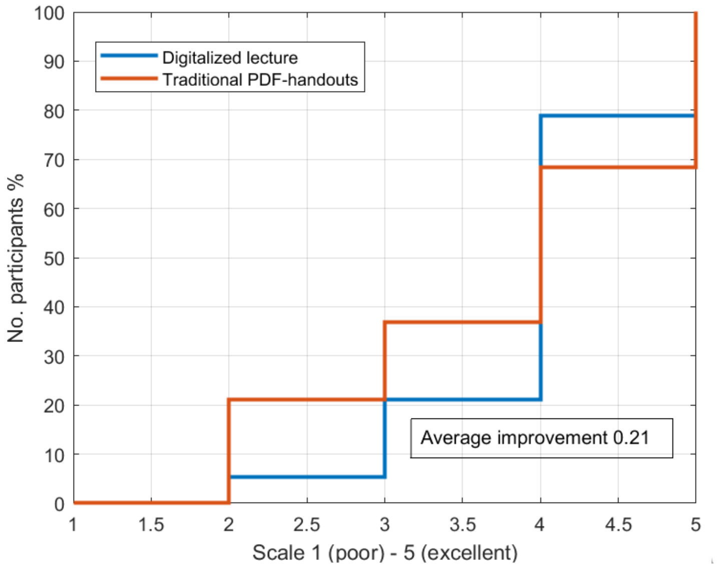


Fig. 2022

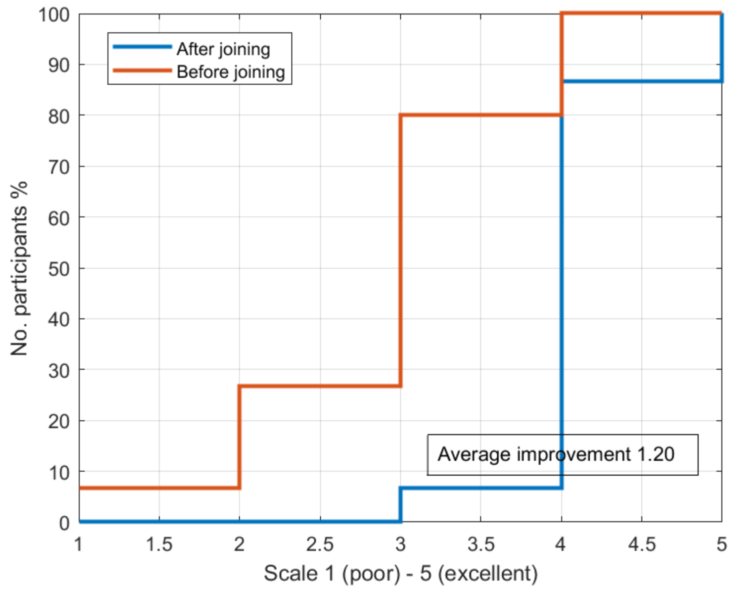


Fig. 2023

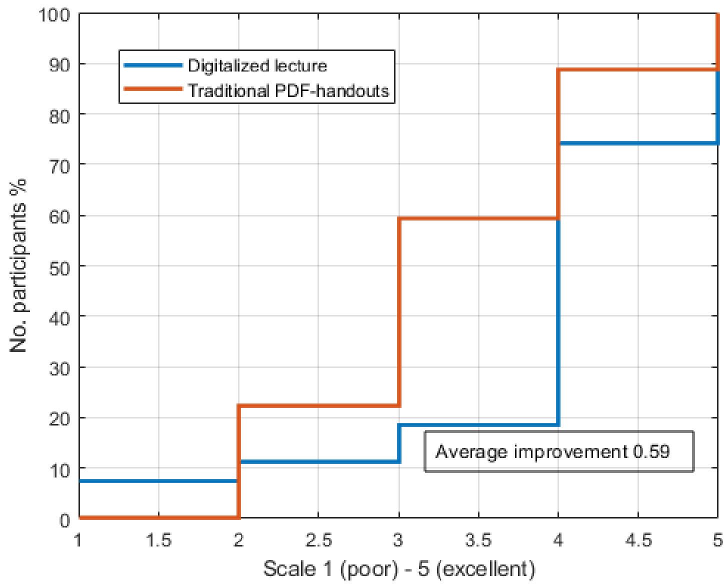


Fig. 2024

[Apostolatos et al. „Teaching the Finite Element Method with Notebooks and Autograded Exercises“, IEEEXplore]

Student survey on the hybrid format of the lecture

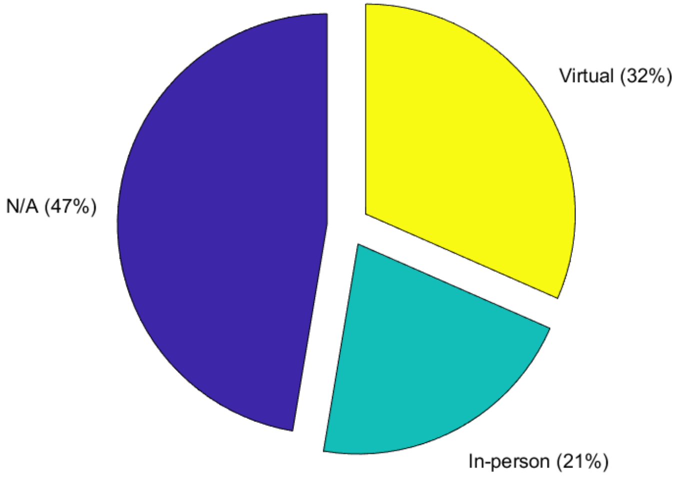


Fig. 2022

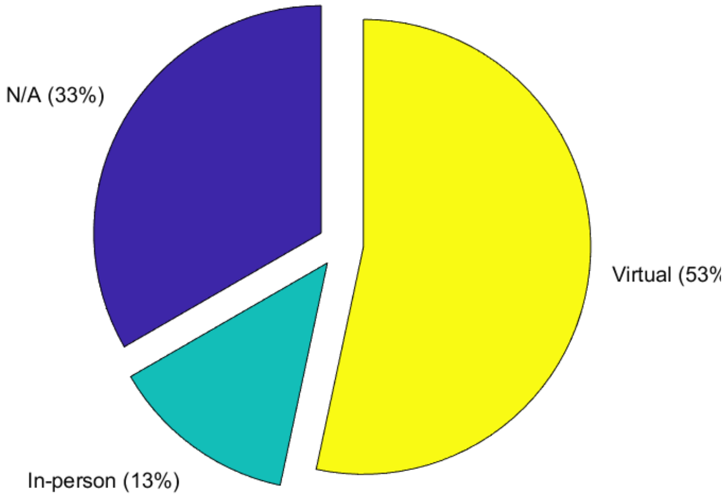


Fig. 2023

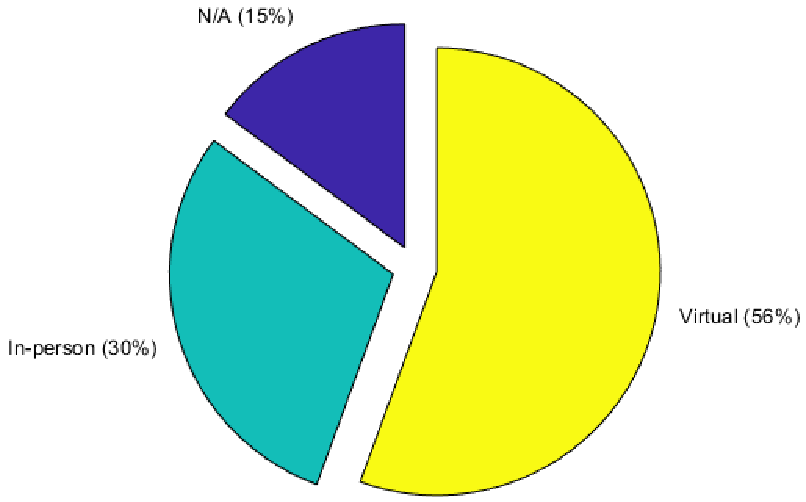


Fig. 2024

*[*Apostolatos et al. „Teaching the Finite Element Method with Notebooks and Autograded Exercises“, IEEEXplore*]()

Student Survey on the Preferred Programming Language

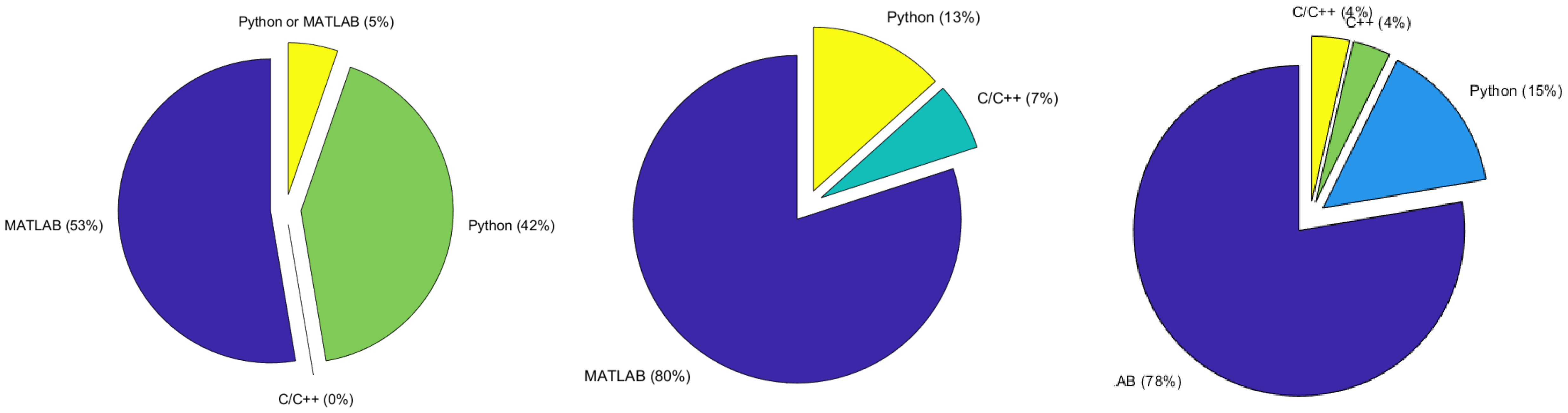


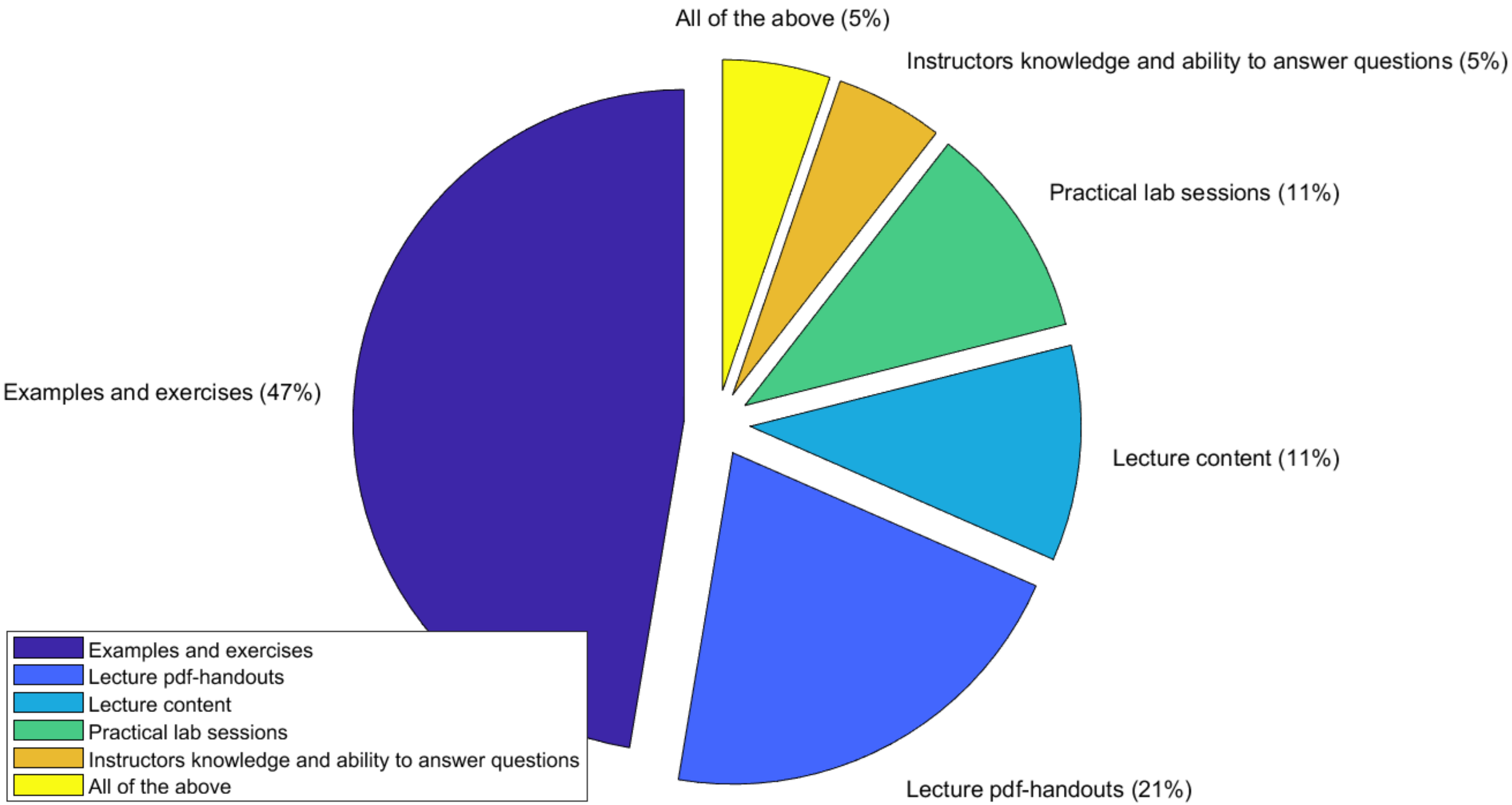
Fig. 2022

Fig. 2023

Fig. 2024

*[*Apostolatos et al. „Teaching the Finite Element Method with Notebooks and Autograded Exercises“, IEEEXplore*]*

Student Survey on the Key Components of the Course



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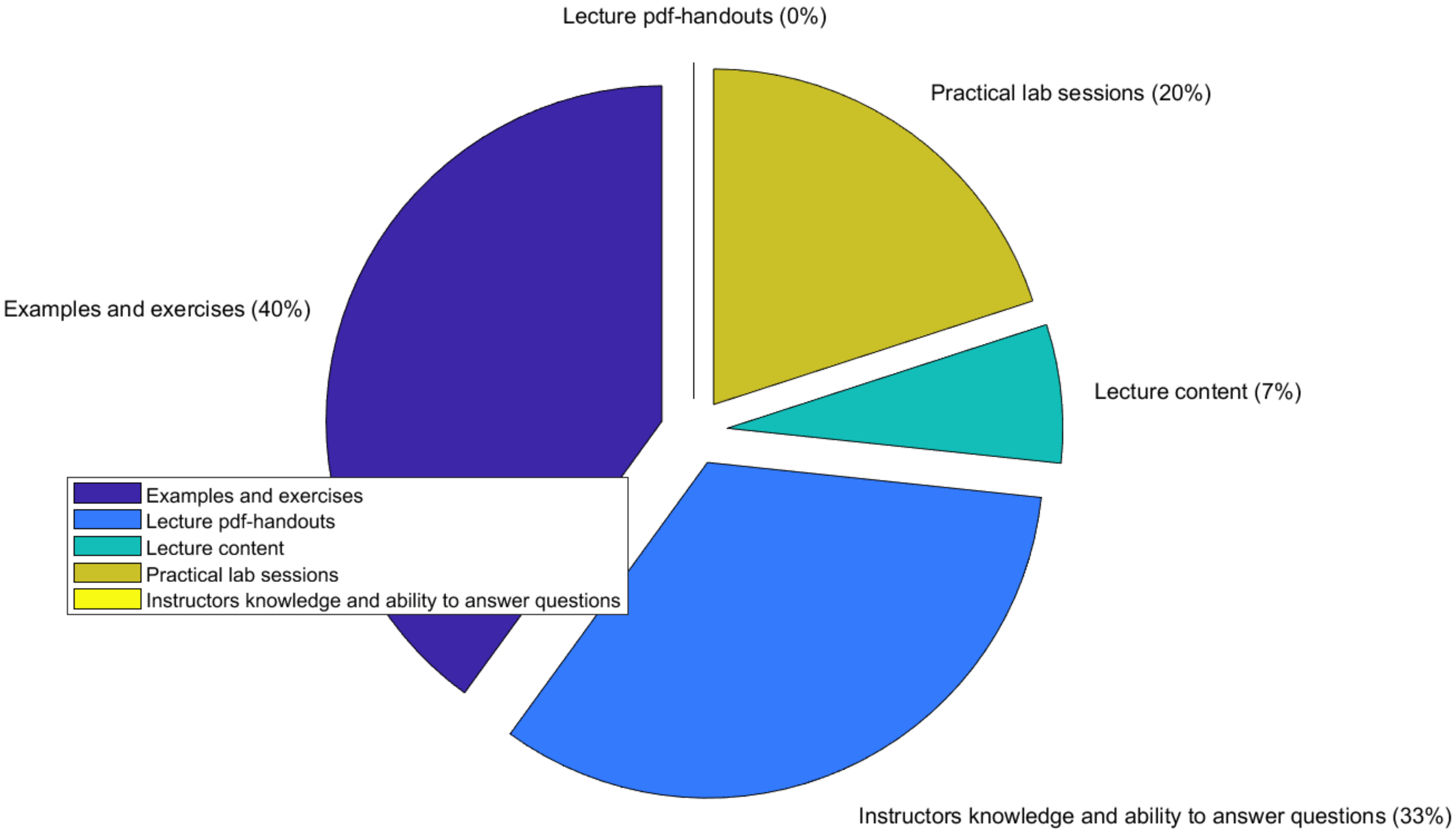

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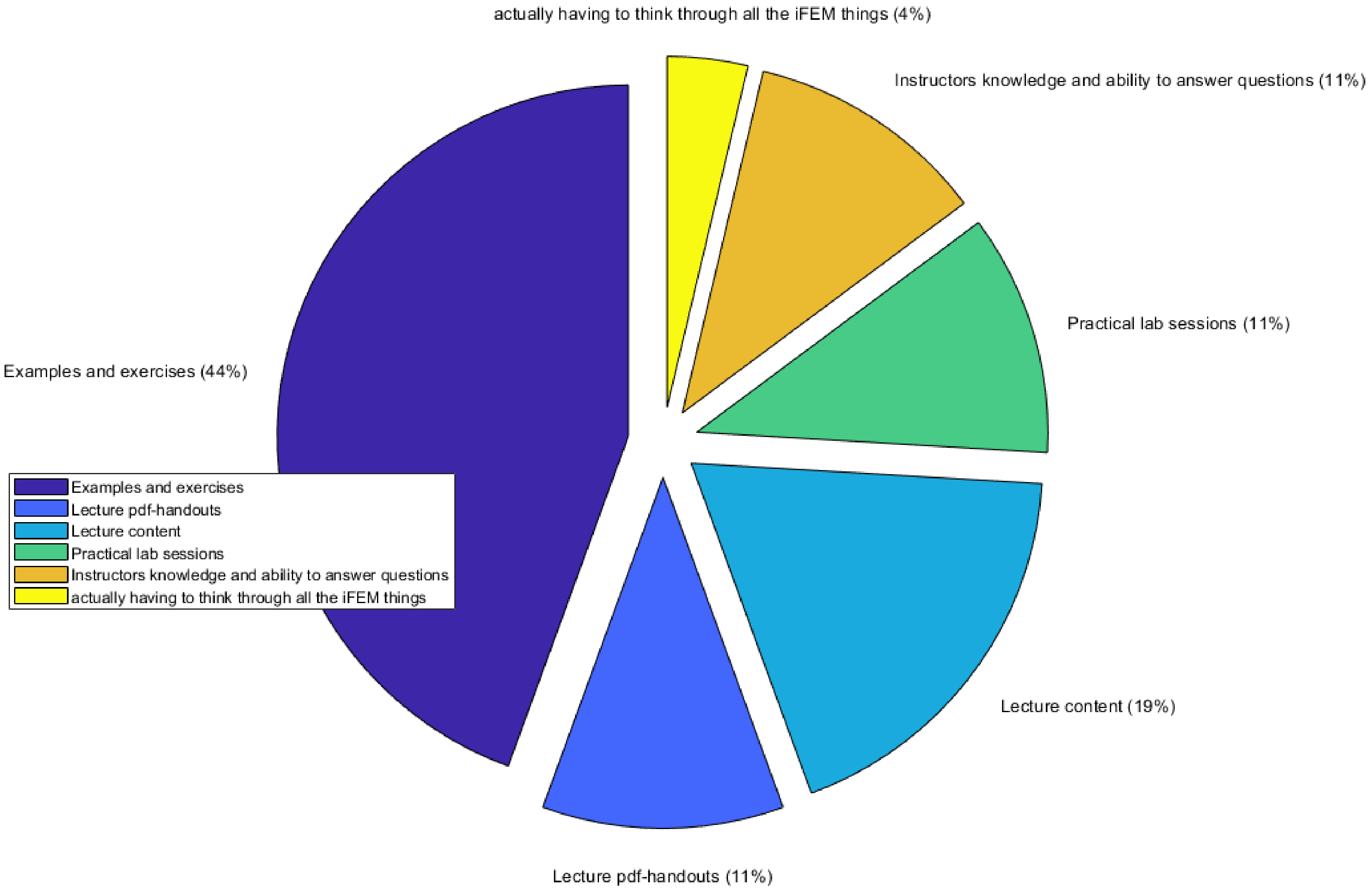


*[Apostolatos et al. „Teaching the Finite Element Method with Notebooks and Autograded Exercises“, IEEEXplore]

Effectiveness of Computational Environments, Weekly Assignments, and MATLAB

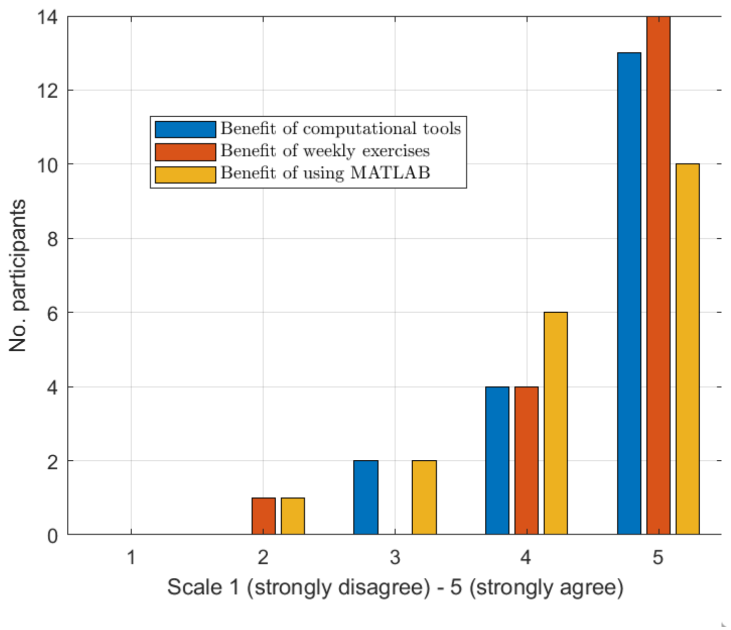


Fig. 2022

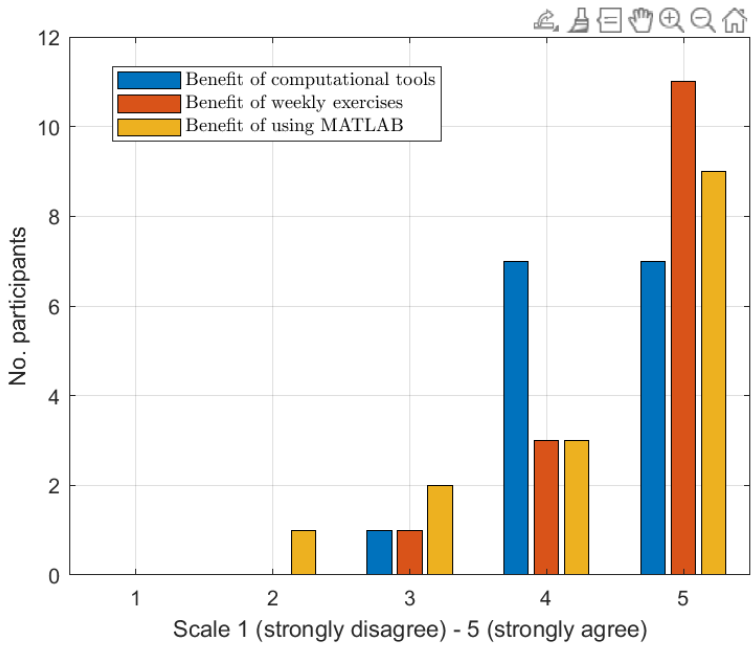


Fig. 2023

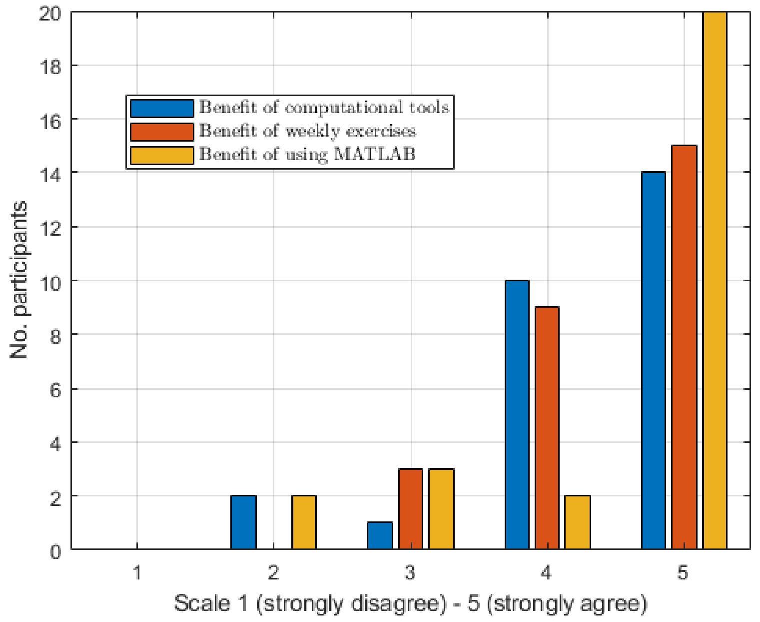
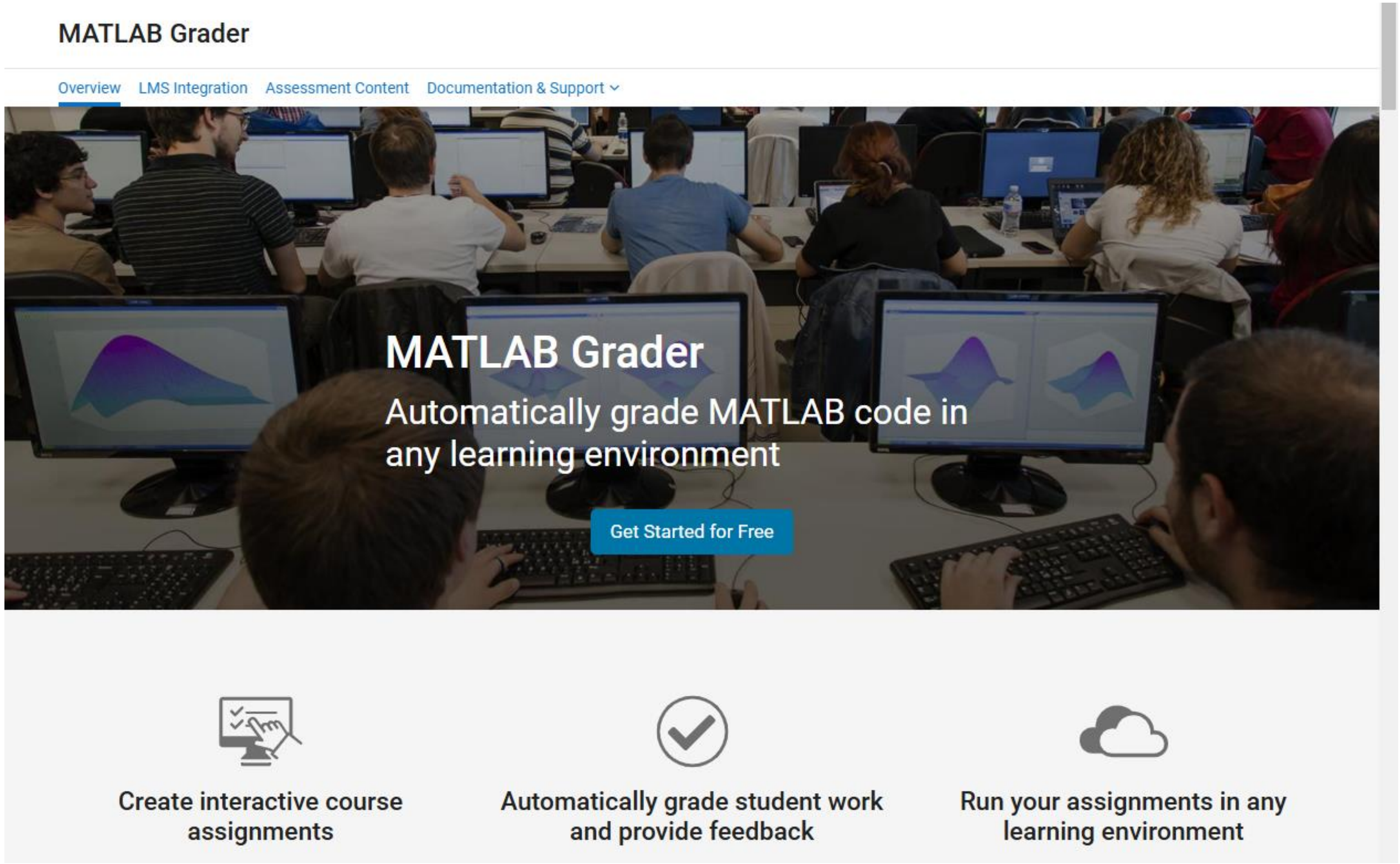


Fig. 2024

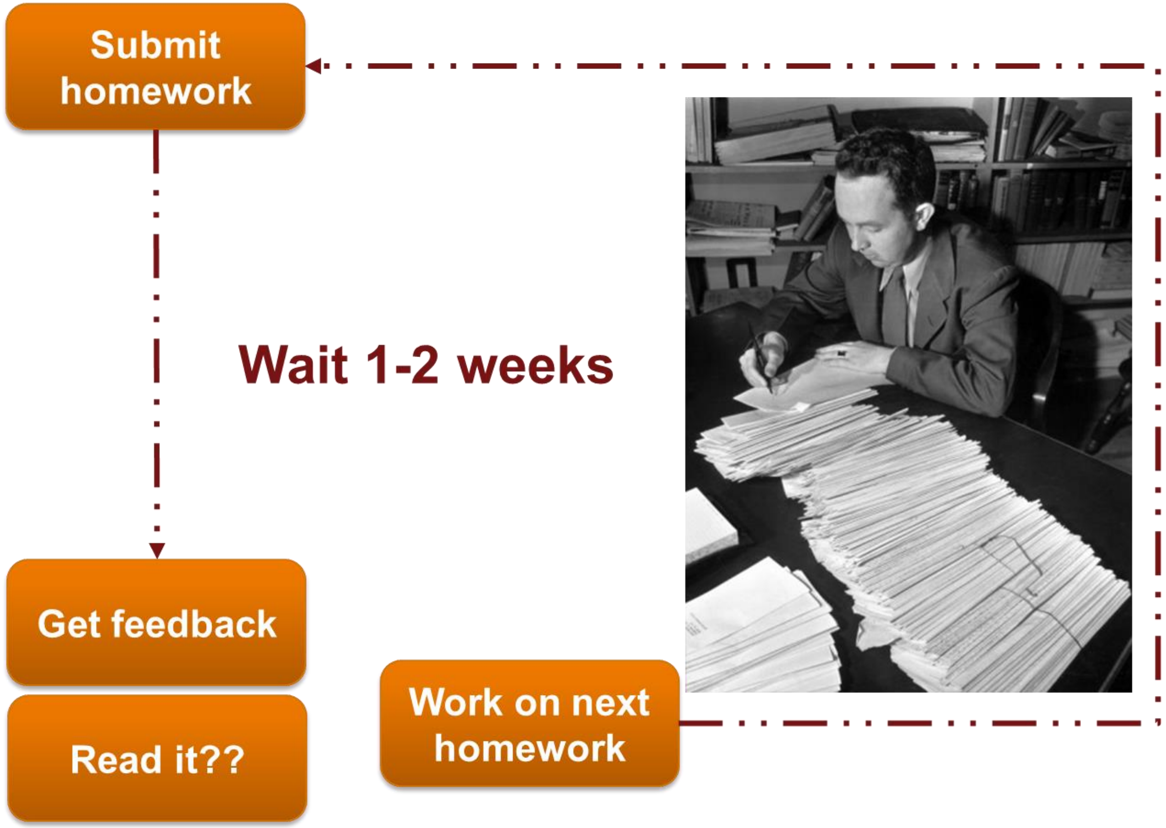
*Apostolatos et al. „Teaching the Finite Element Method with Notebooks and Autograded Exercises“, IEEEXplore

Auto-grading using MATLAB Grader



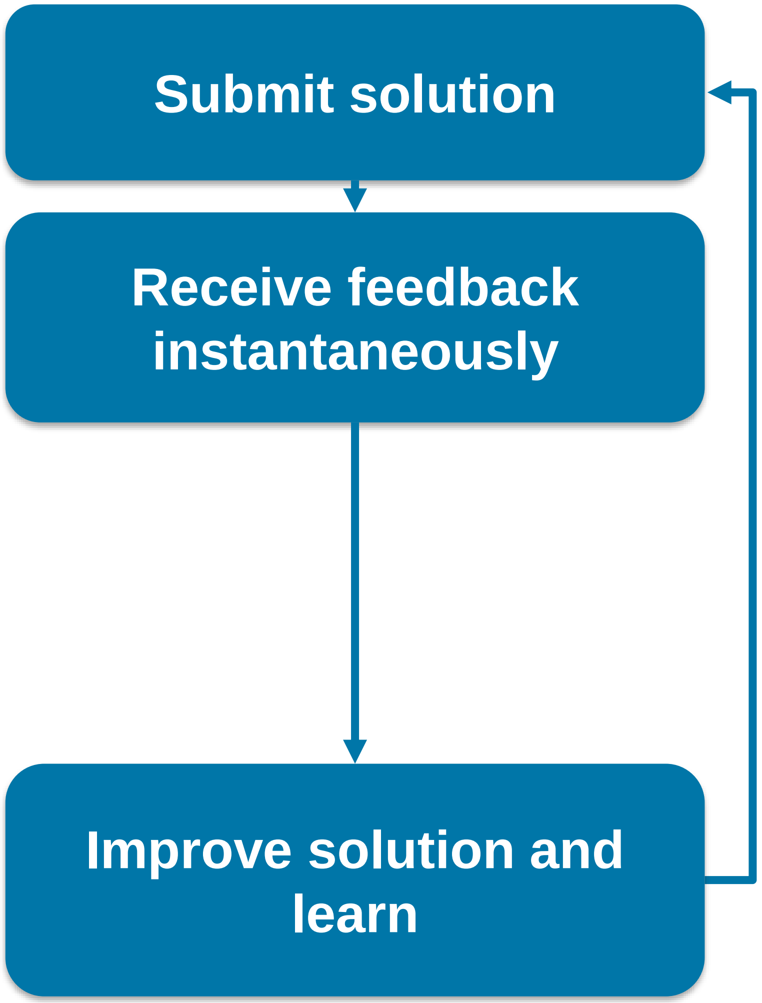
* https://grader.mathworks.com

Conventional Assessment Process



- ***Manual*** grading of solutions
- Provision of ***individual feedback***
- Students ***need to wait*** for the feedback
- ***Lack of resources/teaching assistants*** to provide timely feedback to students
- ***Can't easily obtain*** mid-week progress

Autograding Methods – MATLAB Grader



- ***Automated*** provision of feedback
- ***Real-time*** statistics
- ***Cloud-hosted solution*** no software installation or maintenance is needed
- Enables ***Summative*** and ***Formative*** assessment
- ***Rescoring*** all solutions with no effort

The Learner-View of MATLAB Grader

MATLAB Grader

CONTENTS

MATLAB Grader for Teaching, 14.06.2023 > Set up and use a linear regression model >

Set up and use a linear regression model for the prediction of the gas consumption

0 solutions submitted (max: Unlimited)

Given are four MATLAB variables, namely, the weight `gewicht`, the horsepower `pferdestaerke`, the acceleration `beschleunigung`, and the miles per gallone `meilenProGallone` for a set of cars. The goal is to set up a linear regression model `lm` leveraging these data that predicts the gas consumption. A linear regression model has the following mathematical form:

$$\hat{y} = \beta_0 + \beta_1 x_1 + \ldots + \beta_n x_n$$

where variables $x_1, \ldots, x_n$ are the predictors und where variable $\hat{y}$ is the response. In case of two predictors and one response, one can represent the multiple linear regression through a surface, see the following figure:

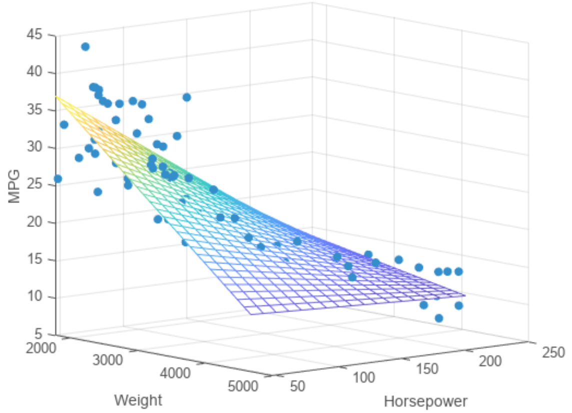


***Fig.** Assignment Description*

MATLAB Grader

CONTENTS

Script Reset MATLAB Documentation

```
% Load the data
myData = load('carsmall', 'Weight', 'Horsepower', 'Acceleration', 'MPG');
weight = myData.Weight;
horsepower = myData.Horsepower;
acceleration = myData.Acceleration;
milesPerGallon = myData.MPG;

% 1. Conversion of the miles per gallon to kilometers per liter
kilometerPerLiter = 0.2*milesPerGallon

% 2. Setting up a MATLAB table
% predictorsAndReponse =

% 3. Setting up a linear regression model
% lm =

% 4. Predict the gas consumption in kilometer per liter for this new set of variables and
%    plot the diagram horsepower2 (X-Achse) vs the newly computed gas consumption (Y-axis)
[lm2, weight2, horsepower2, acceleration2] = ...
    computeMyMultipleLinearRegression(weight, horsepower, acceleration, milesPerGallon);
% kilometerPerLiter2 =
% plot
```

Run Script

Assessment: 0 of 5 Tests Passed (0%) Submit

Is the gas consumption correctly converted in kilometers per liter? 0% (20%)

Variable kilometerPerLiter has an incorrect value.

The conversion factor for the conversion of the miles per gallon to kilometers per liter is **0.425144**

***Fig.** Code-Editor and automated feedback*

The Instructor-View of MATLAB Grader – Reference Solution

MATLAB Grader

CONTENTS

Problem Type *

(•) Script ( ) Function

Code

Reference Solution | Learner Template

```
% Load the data
myData = load('carsmall', 'Weight', 'Horsepower', 'Acceleration', 'MPG');
weight = myData.Weight;
horsepower = myData.Horsepower;
acceleration = myData.Acceleration;
milesPerGallon = myData.MPG;

% 1. Conversion of the miles per gallon to kilometers per liter
conversionFactor = 0.425144;
kilometerPerLiter = milesPerGallon*conversionFactor;

% 2. Setting up a MATLAB table
predictorsAndReponse = table(weight, horsepower, acceleration, ...
    kilometerPerLiter, VariableNames={'weight', 'horsepower', 'acceleration', 'kilometerPerLiter'});

% 3. Setting up a linear regression model
lm = fitlm(predictorsAndReponse, 'ResponseVar', 'kilometerPerLiter');

% 4. Predict the gas consumption in kilometer per liter for this new set of variables and
%    plot the diagram horsepower2 (X-Achse) vs the newly computed gas consumption (Y-axis)
[lm2, weight2, horsepower2, acceleration2] = ...
    computeMyMultipleLinearRegression(weight, horsepower, acceleration, milesPerGallon);
kilometerPerLiter2 = predict(lm2, [weight2, horsepower2, acceleration2]);
hReference = plot(horsepower2, kilometerPerLiter2);

% Save the figure data in a separate variable, because the figure-object is overwritten by the learner solution
XDataReference = hReference.XData;
YDataReference = hReference.YData;
```

Fig. *Reference solution*

MATLAB Grader

CONTENTS

Problem type *

(•) Script ( ) Function

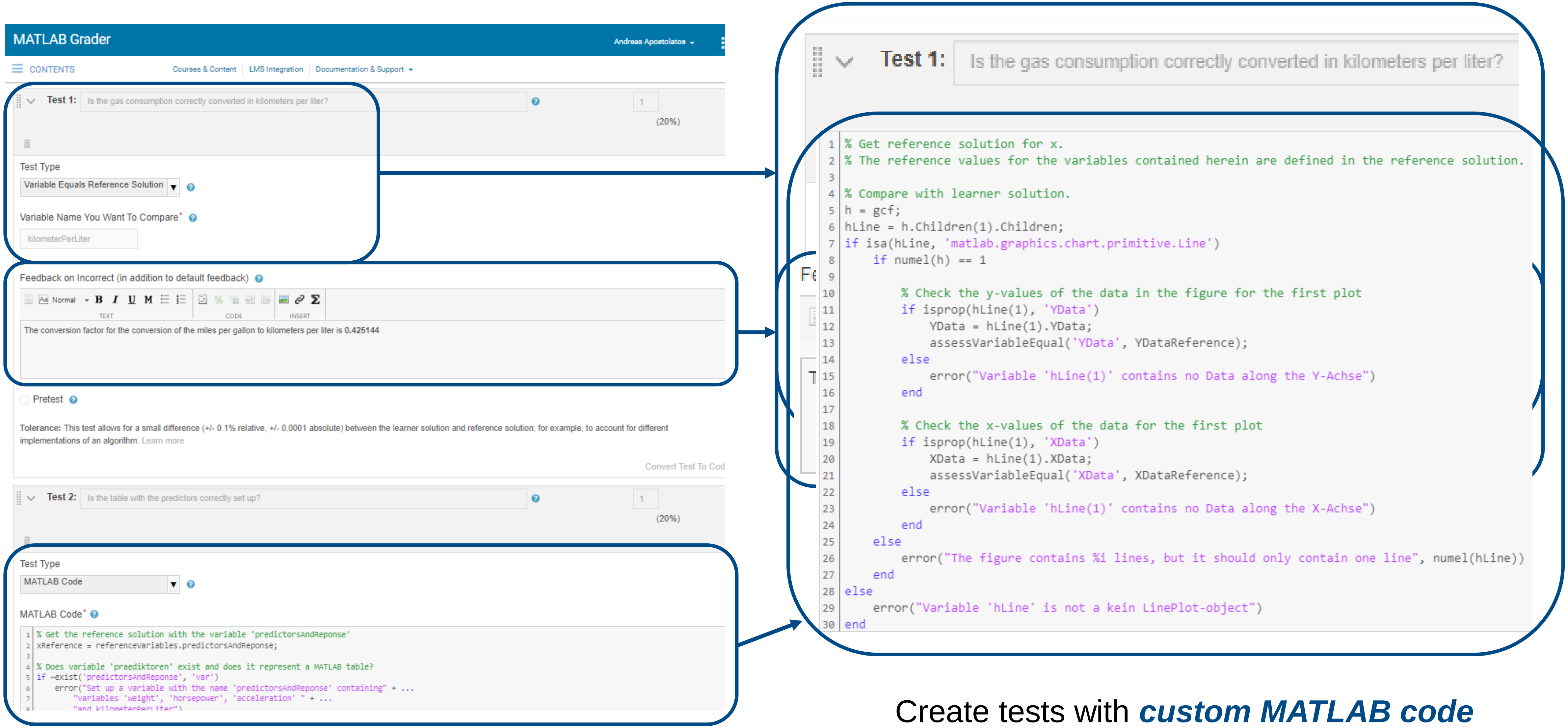
Code

Reference Solution | Learner Template

```
% Load the data
myData = load('carsmall', 'Weight', 'Horsepower', 'Acceleration', 'MPG');
weight = myData.Weight;
horsepower = myData.Horsepower;
acceleration = myData.Acceleration;
milesPerGallon = myData.MPG;

% 1. Conversion of the miles per gallon to kilometers per liter
% kilometerPerLiter =

% 2. Setting up a MATLAB table
% predictorsAndReponse =

% 3. Setting up a linear regression model
% lm =

% 4. Predict the gas consumption in kilometer per liter for this new set of variables and
%    plot the diagram horsepower2 (X-Achse) vs the newly computed gas consumption (Y-axis)
[lm2, weight2, horsepower2, acceleration2] = ...
    computeMyMultipleLinearRegression(weight, horsepower, acceleration, milesPerGallon);
% kilometerPerLiter2 =
% plot
```

Fig. *Student template*

The Instructor-View of MATLAB Grader – Tests



Create tests with ***custom MATLAB code***

The Instructor-View of MATLAB Grader - Statistics

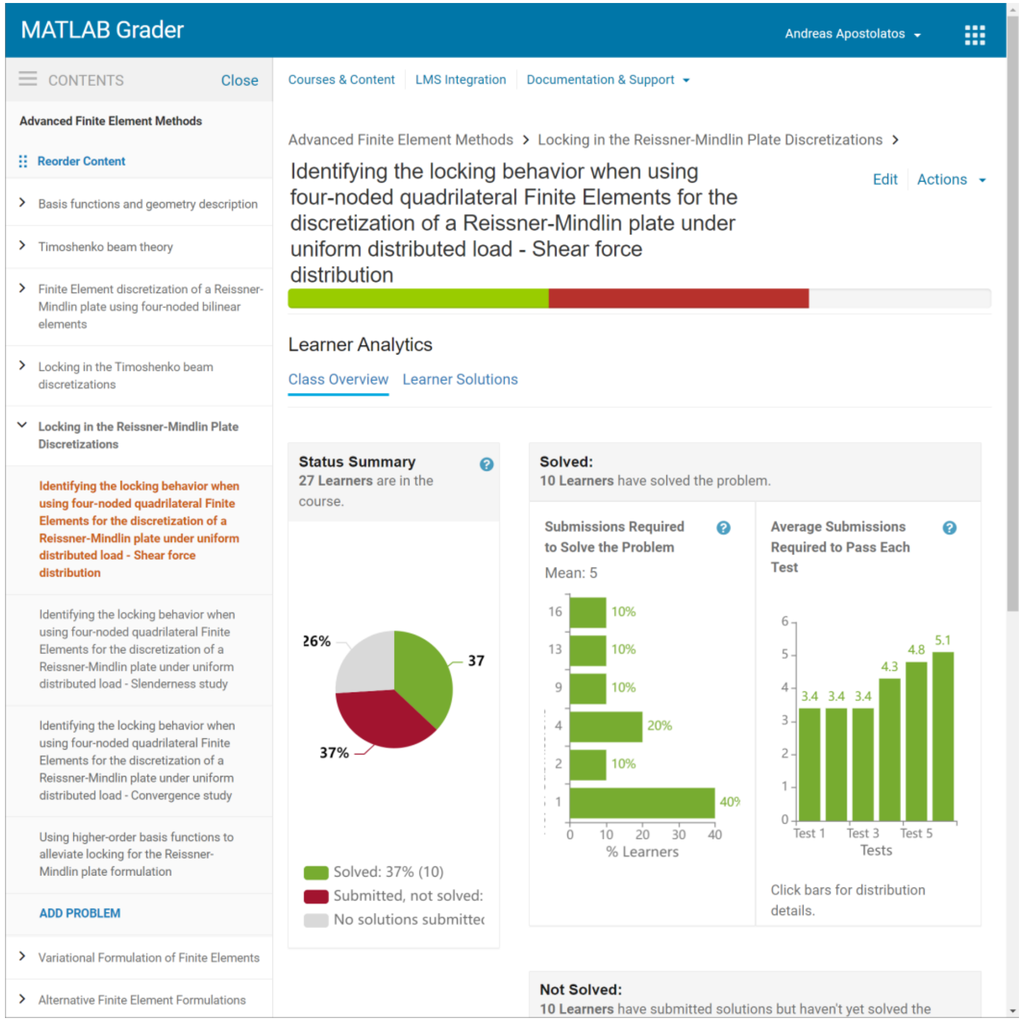


Fig. Classroom-Statistics in MATLAB Grader

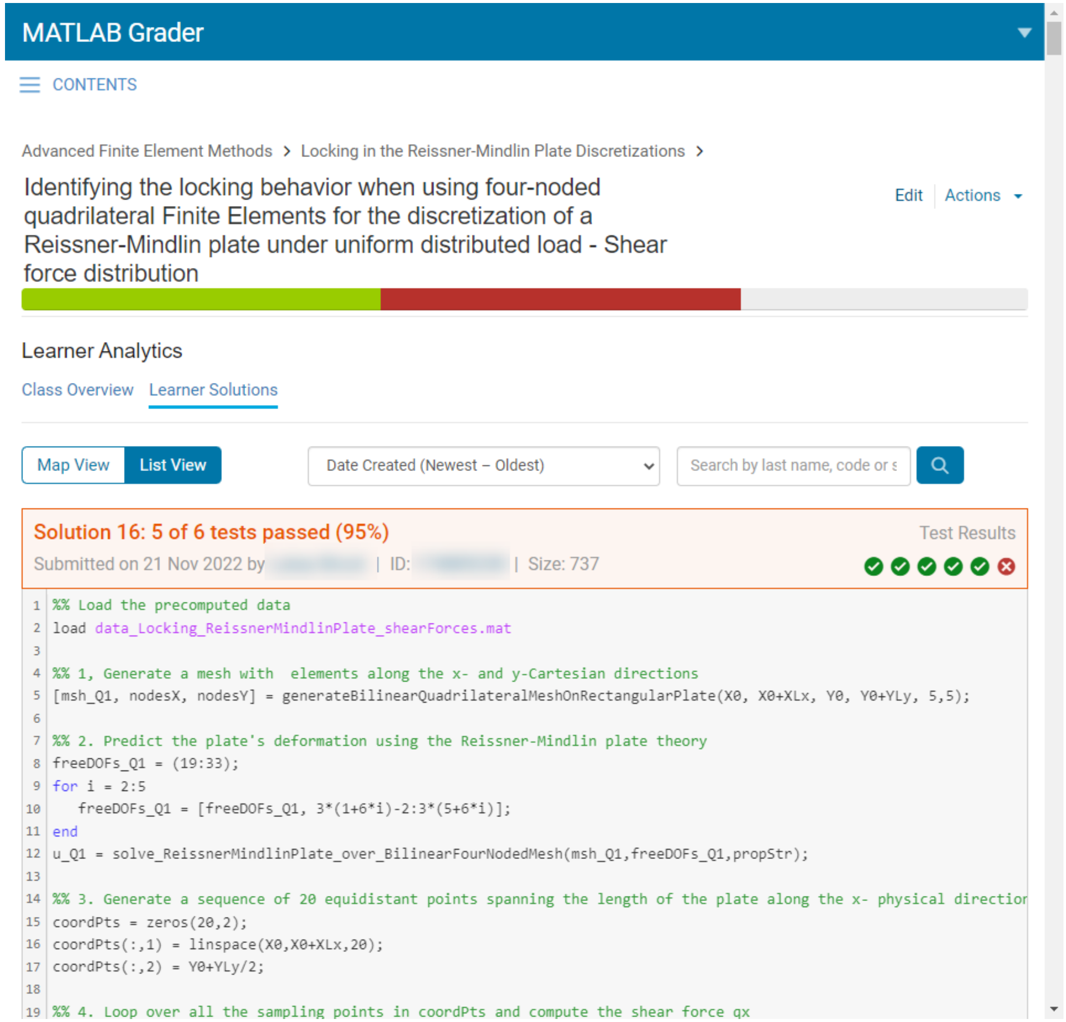


Fig. Individual-Statistics in MATLAB Grader

Sample Problems from MathWorks

MATLAB Grader

Andreas Apostolatos

CONTENTS | Courses and Collections | LMS-Integration | Documentation and Support

Add Problem

Sample Problems from MathWorks

Getting Started with MATLAB Grader
13 Problems

Calculus I
Created By: MathWorks
10 Problems

Statistics
Created By: MathWorks
15 Problems

Electric Circuits
Created By: MathWorks
16 Problems

Digital Signal Processing
Created By: MathWorks
10 Problems

System Dynamics and Control
Created By: MathWorks
10 Problems

Dynamics
Created By: MathWorks
10 Problems

Introduction to Programming
Created By: Eric Davishahl
111 Problems

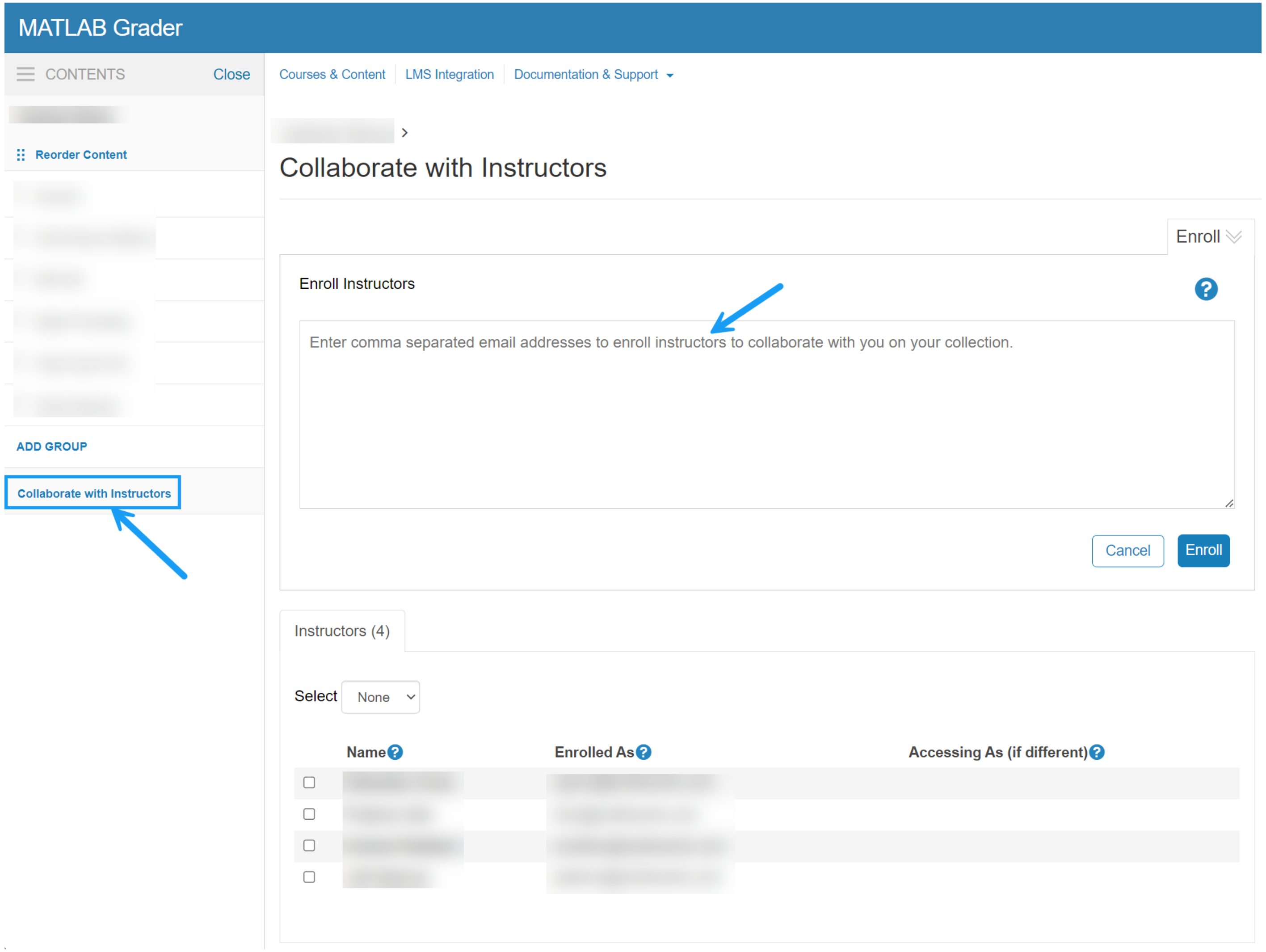
Calculus II
Created By: MathWorks
10 Problems

Numerical Methods
Created By: MathWorks
10 Problems

Symbolic Math Toolbox
Created By: MathWorks
10 Problems

**Reach out to a MathWorks representative (aapostol@mathworks.com) to grant you access*

Collaboration with other Instructors



- Use Collections to share exercises with other instructors
- Adjust dynamically the access to the shared exercises
- Use Collections as pools of exercises to add to different courses

Moodle-Integrated Version of MATLAB Grader

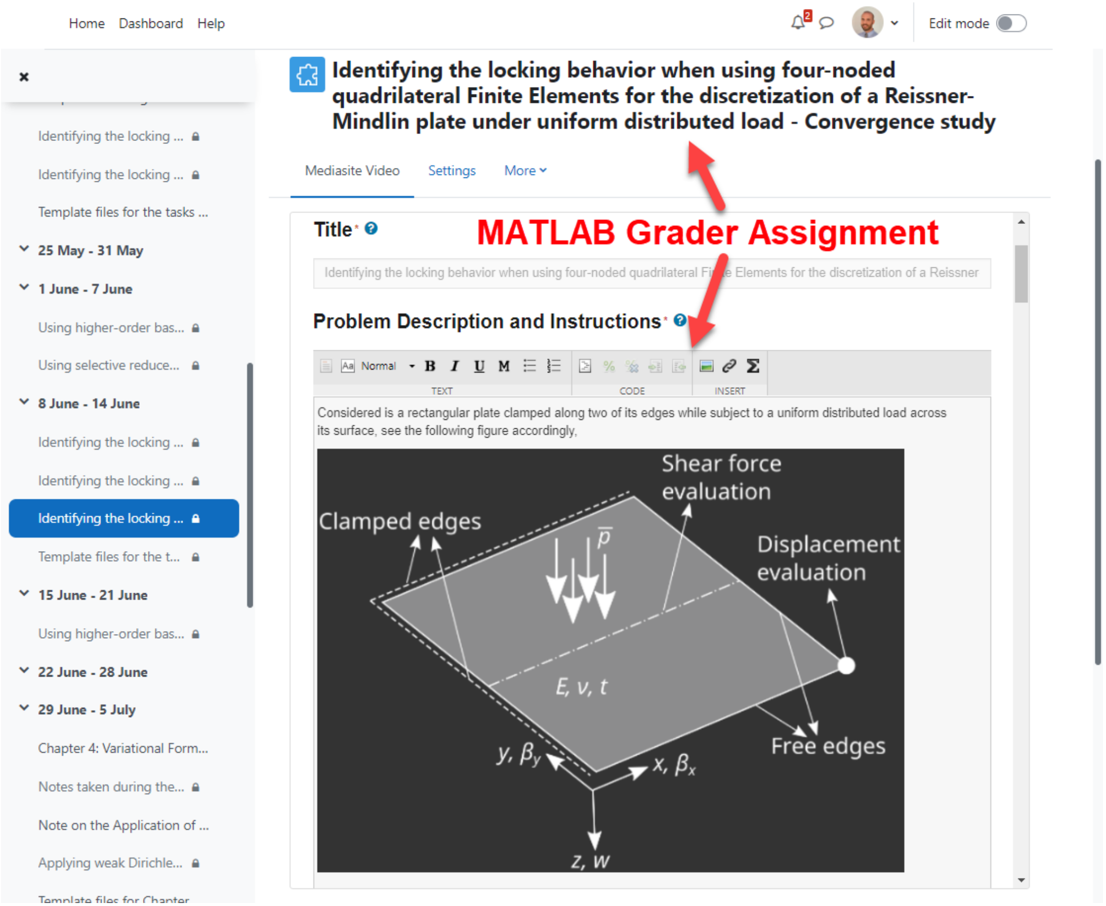


Fig. *LMS-integrated Version von MATLAB Grader*

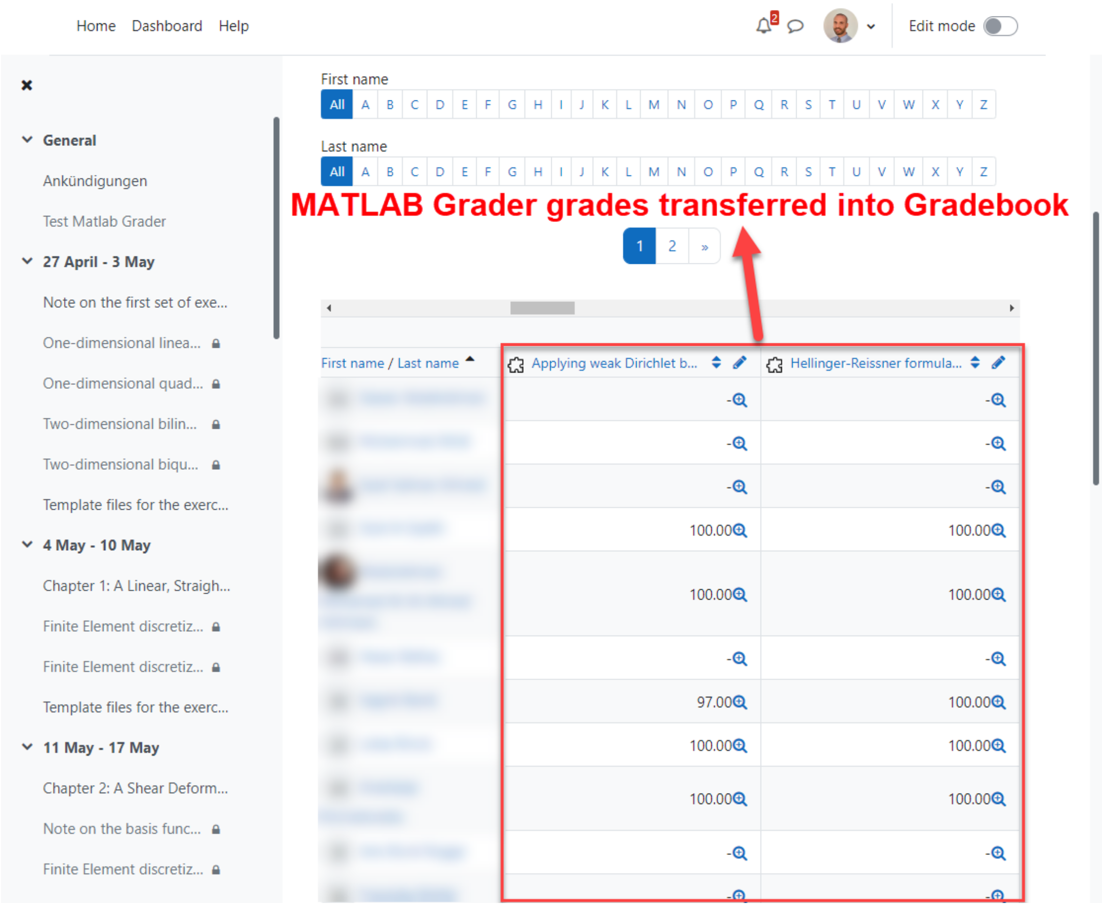


Fig. *Transfer of the Grades in the LMS-Grade Book*

MATLAB Grader in Practice

* *Apostolatos, Andreas, Sebastian Gross, and Kai-Uwe Bletzinger. "Teaching the Finite Element Method with Notebooks and Autograded Exercises." 2022 IEEE German Education Conference (GeCon). IEEE, 2022.*

Summary

- MATLAB Live Editor enables the standardization of teaching materials
- MATLAB Grader enables, among other:
  - ***Flipped Classroom*** among other modern teaching approaches
  - ***Automatic grading*** of MATLAB code
  - Preparation of ***digital***, ***informative***, and ***reusable*** assignments
    - ***Immediate*** feedback
    - ***Real-time statistics***
    - ***Formative*** and ***Summative*** Assessment
    - ***Assignment sharing*** with other instructors
  - ***Integration into standard LMS platforms*** (Moodle, Canvas, ILIAS, etc.)
    - Simple ***assignment distribution***
    - ***Transfer of grades*** into the LMS gradebook