Institute for AI and Autonomous Systems

Hochschule Bonn-Rhein-Sieg
University of Applied Sciences

e2xgrader: An Add-on for Improved Grading and Teaching with Jupyter Notebooks at Scale

Tim Metzler
Mohammad Wasil
Prof. Dr. Paul G. Plöger

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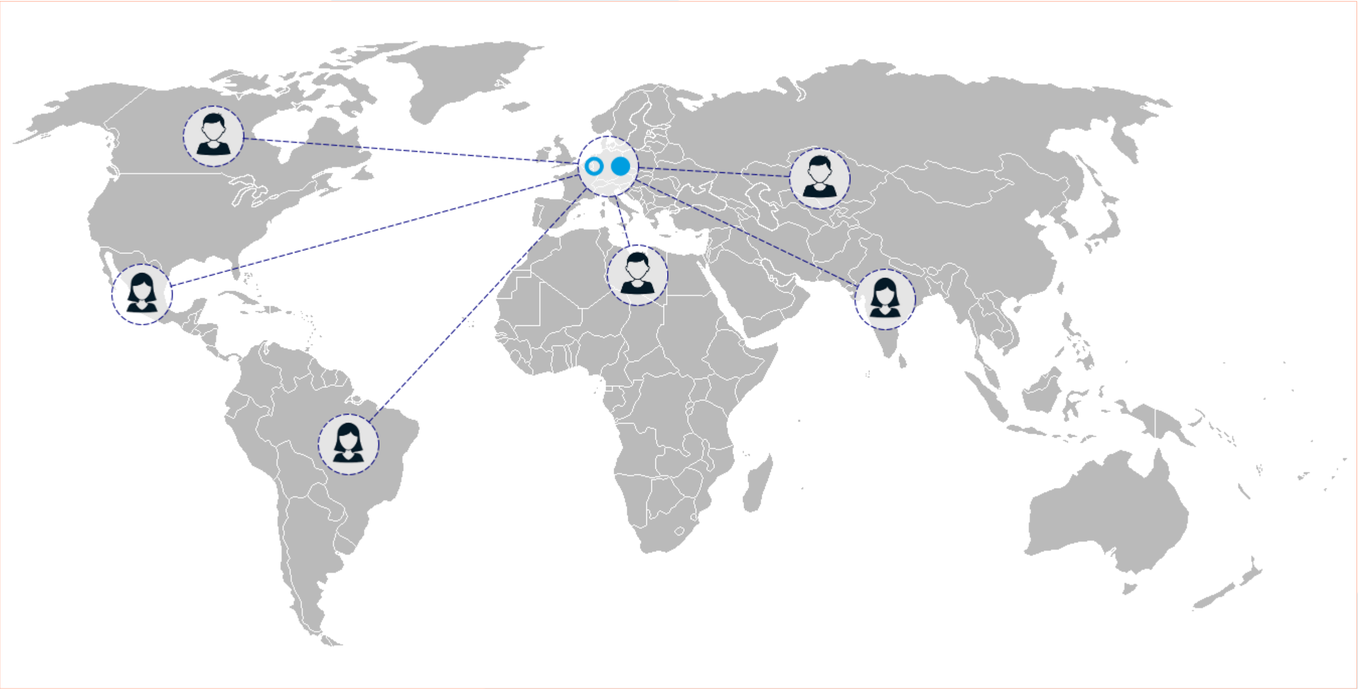
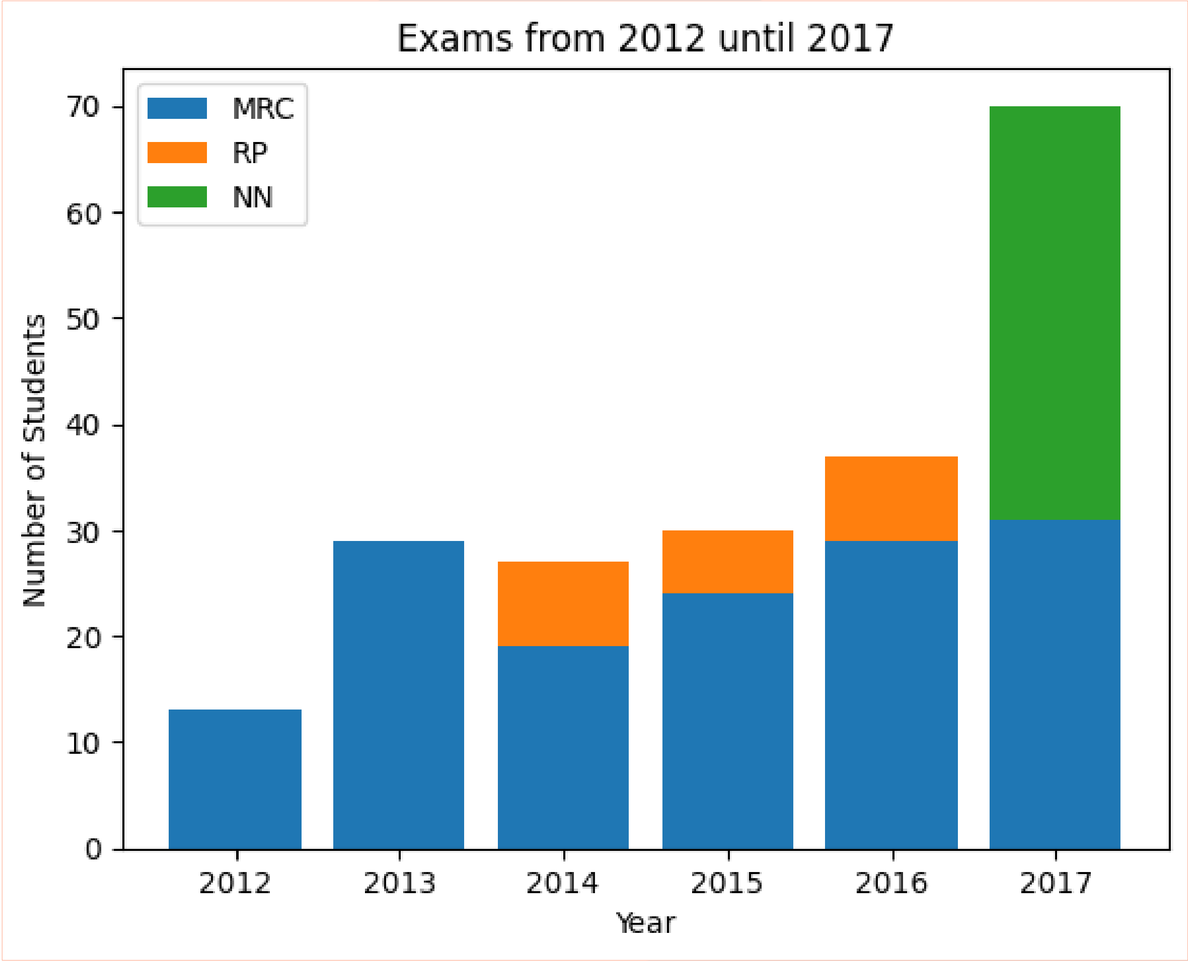
Who are we?

- Hochschule Bonn-Rhein-Sieg
  Department of Computer Science
  Master of Autonomous Systems (robotics, machine learning, AI)
- Tim Metzler
- Mohammad Wasil
- Dr. Paul G. Plöger

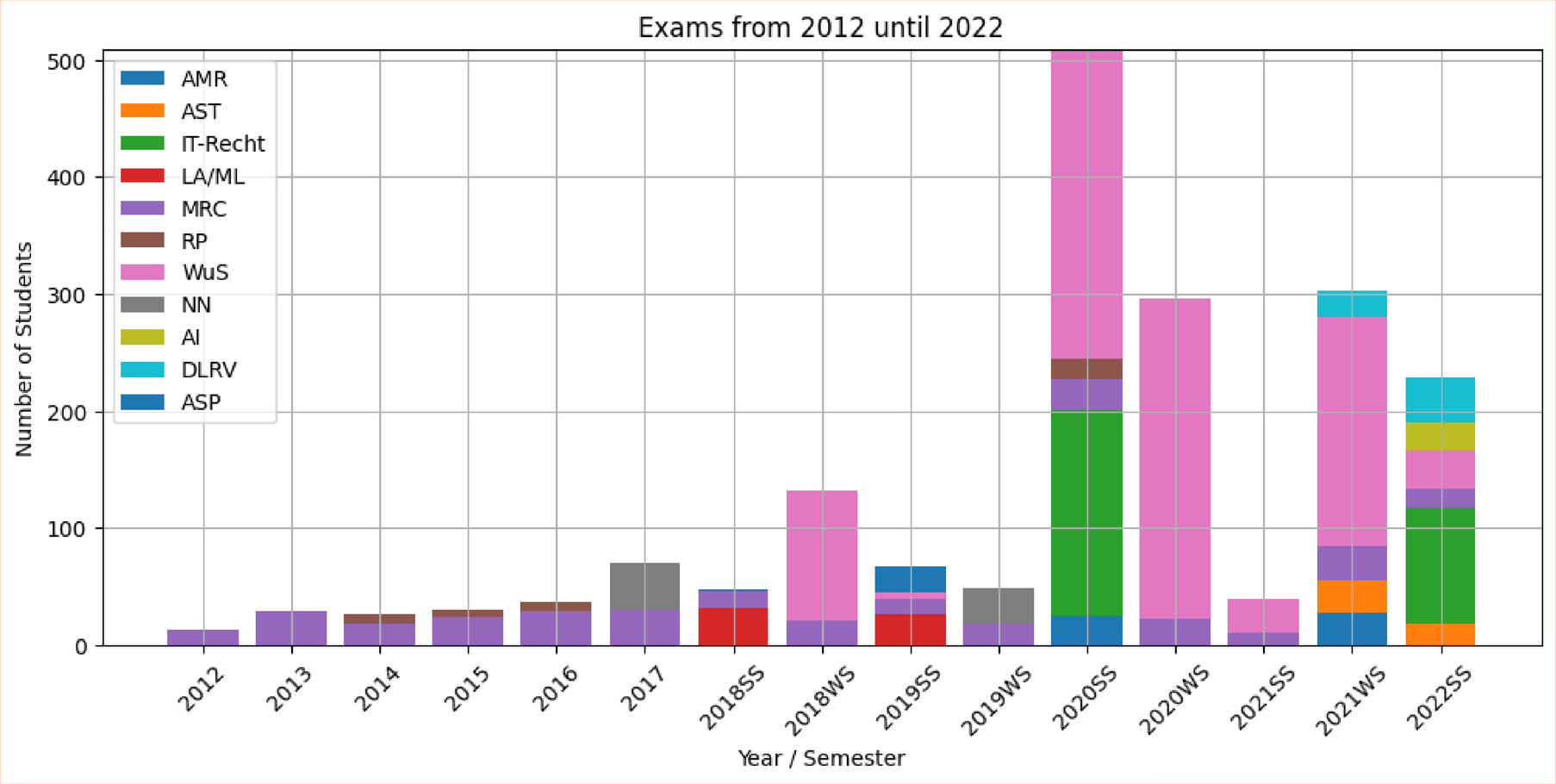


Scaling Up Exams and Assignments with Jupyter Notebooks

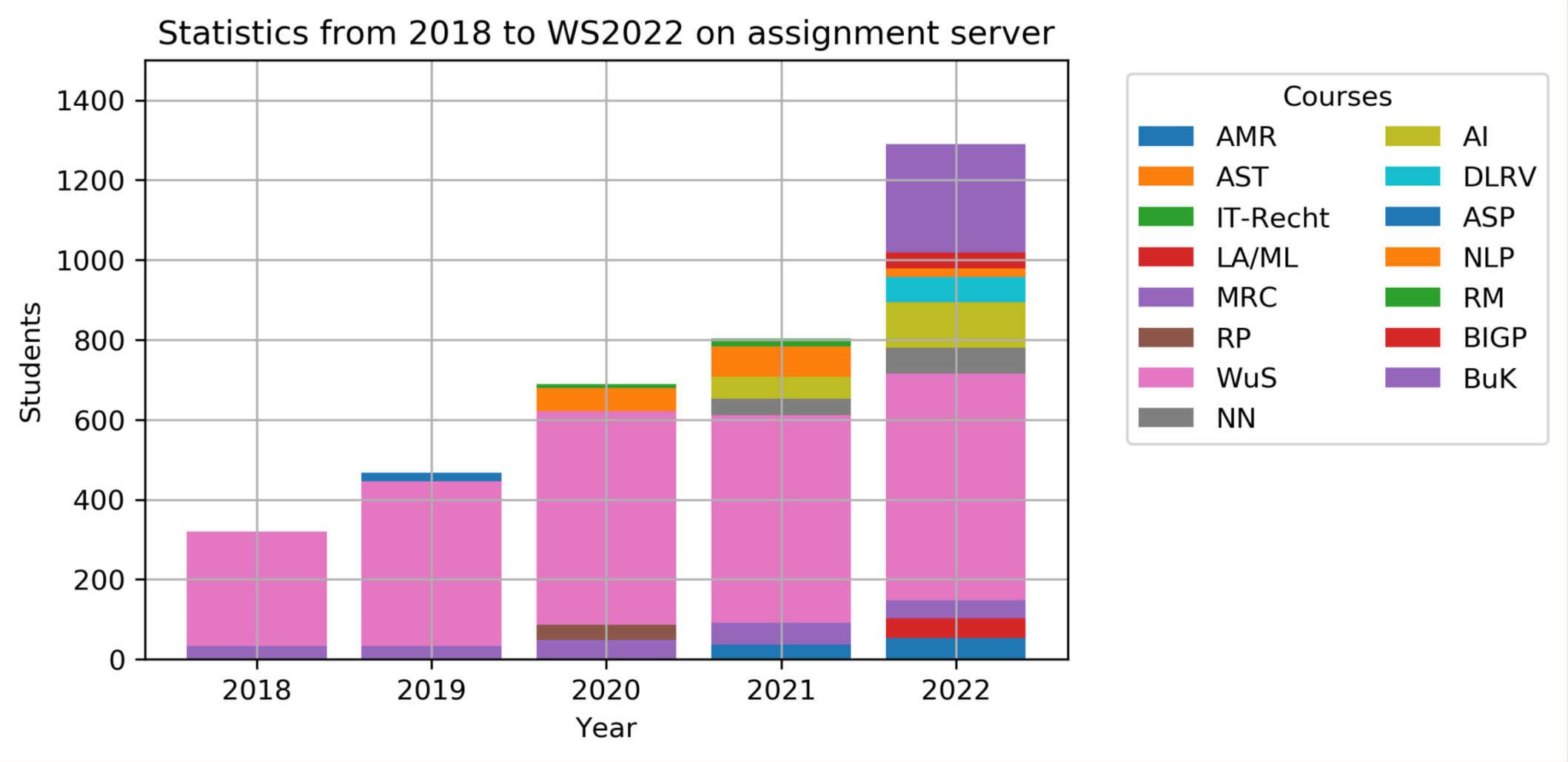
- Started using Jupyter Notebooks for exams and assignments in 2012
- Students solved assignments on their own machine
- Exams: Initially used laptops with USB sticks for distribution
- Challenges in scaling up:
  - Manual grading process
  - Difficulty tracking changes made by students
  - Version conflicts



Scaling Up Exams and Assignments with Jupyter Notebooks



Students enrolled in courses with Jupyter Notebook assignments



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Scaling Up to Large Classes: Challenges and Solutions

From courses with 20 students to courses with 500 students with nbgrader

- Started using nbgrader in 2017 locally and 2018 on a JupyterHub
- Problems were amplified:
  - Students deleted, copied or reordered cells
  - Students put their answers in the wrong cells
  - Many submissions required manual fixing to make them autogradable

Pros and Cons of nbgrader for Grading Jupyter Notebooks

- Benefits:
- Frontend for manual grading
- Autograding
- Feedback for students
- Adds structure via different cell types for solutions, tests and descriptions
- Exchange for releasing, collecting and submitting assignments

- Limitations:
- Appears as a normal notebook to students, leading to potential issues with accidental **deletion, reordering, or copying of cells**
- Graders do usually not create proper ids for cells and may **forget** to switch cell types
- Customizing nbgrader's grading process can be complex, making it challenging to meet the unique needs of different courses and instructors.

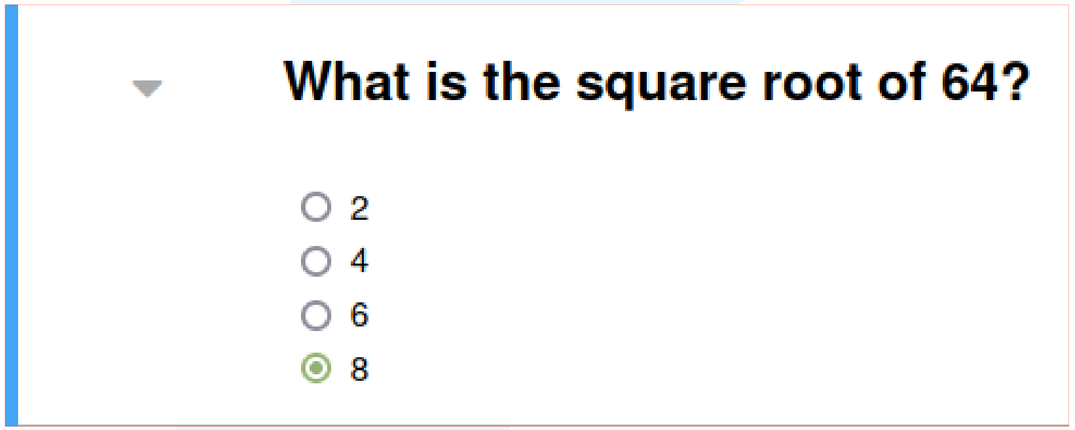
e2xgrader

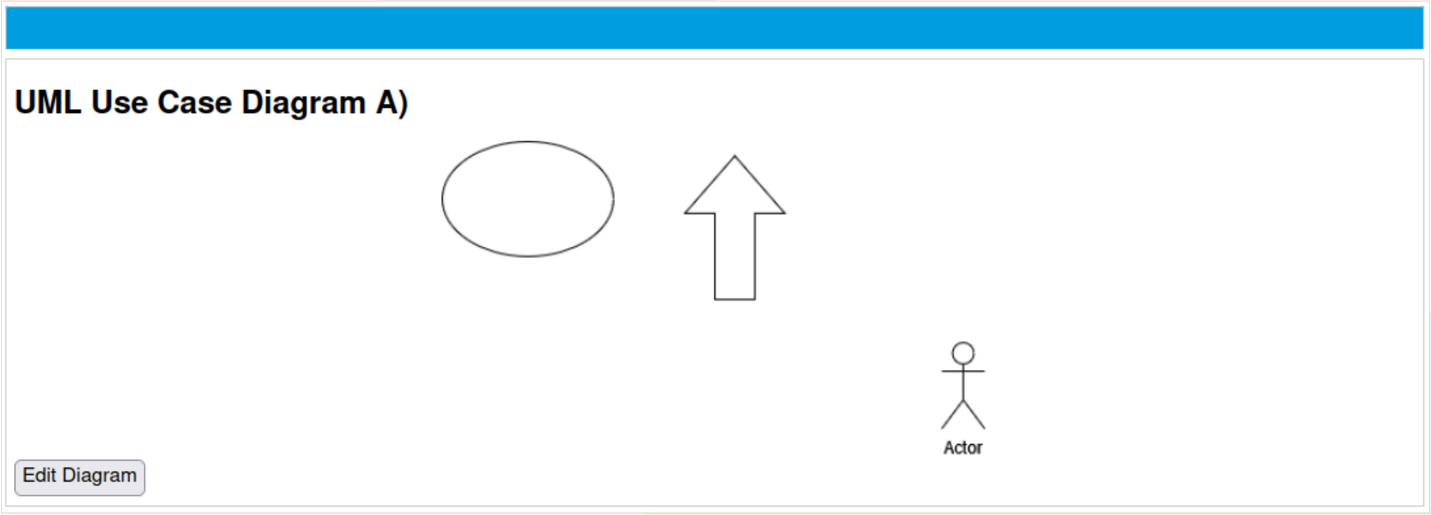
- Add-on for nbgrader
- Customizable components
- Extensions to restrict students from changing the structure of the notebook
- New cell types
- Customizable autograders
- Authoring component for creating notebooks from small units using templates
- Can switch between teacher mode, student mode and student exam mode

New Cell Types

- Custom Markdown Cells:
- Single choice
- Multiple choice
- Interactive diagrams via diagrams.net

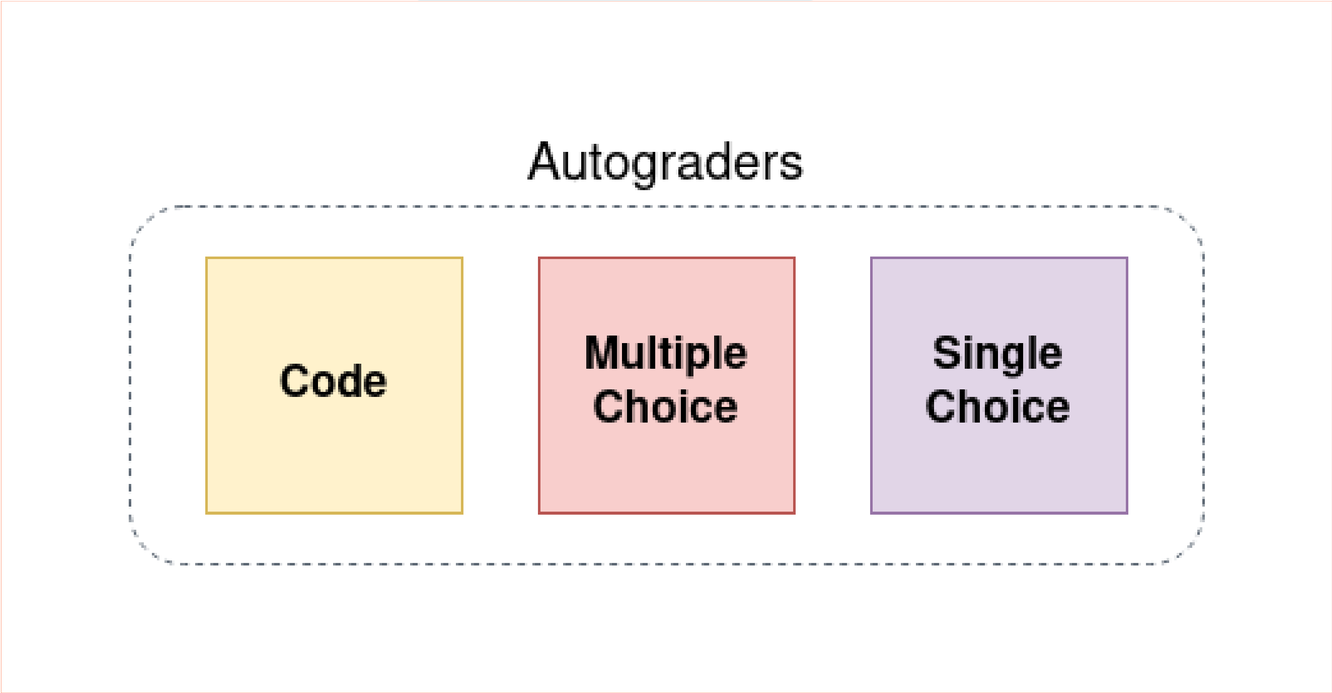
- Answers are stored in the metadata of the cell. The cells render function is replaced by a custom renderer.





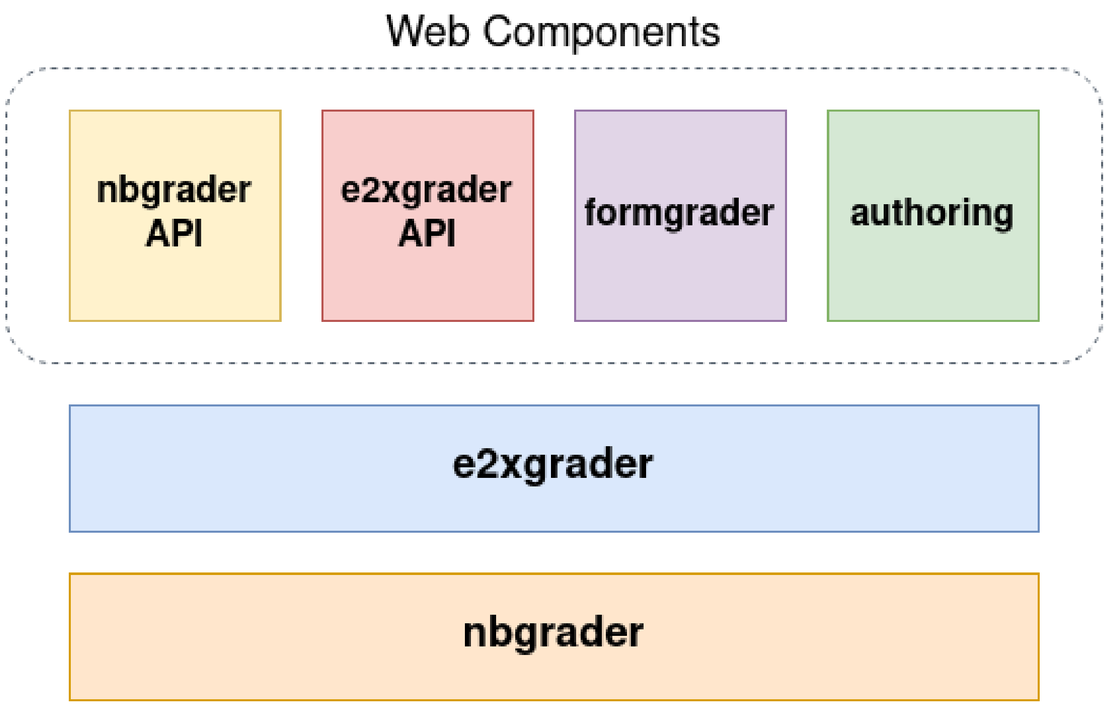
Custom Autograders

- e2xgrader allows for custom autograders to be added via the nbgrader_config.py file
- Multiple choice and single choice cell graders have already been implemented in e2xgrader
- The code grader has also been adapted to fit e2xgrader's architecture
- The appropriate grader is automatically chosen based on the cell type
- If no custom grader is available, e2xgrader falls back to the nbgrader autograder
- This allows for greater flexibility and customization in grading student assignments.



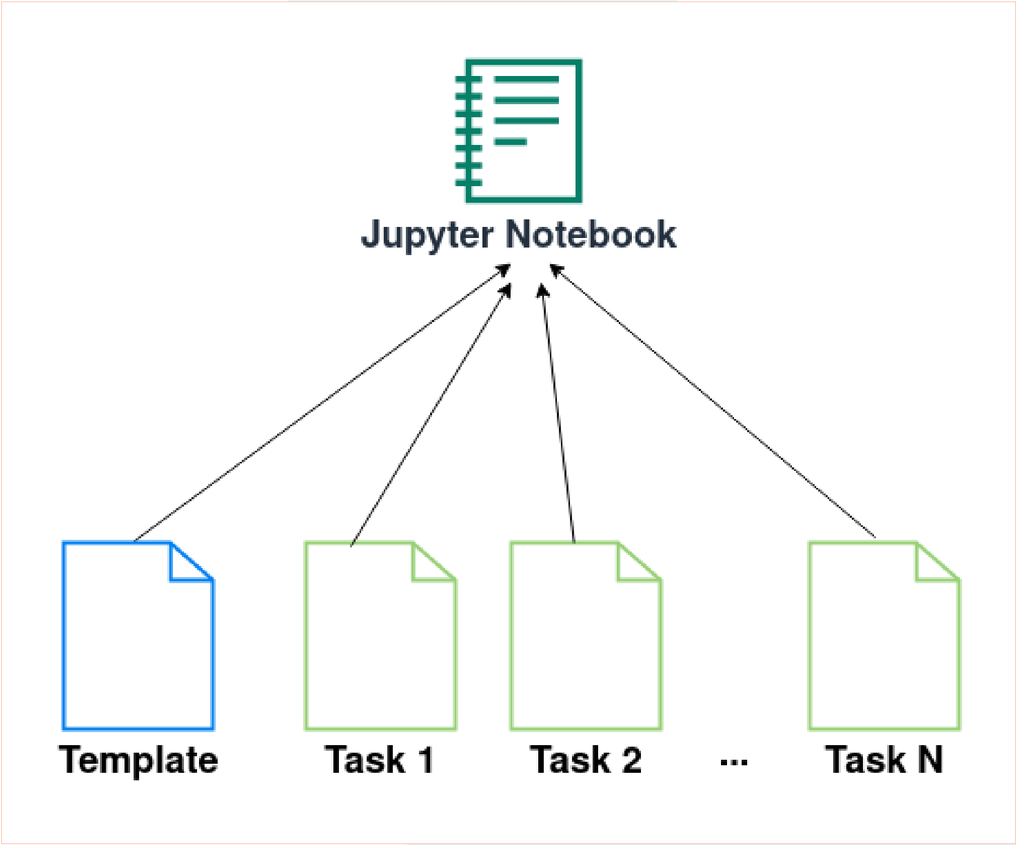
Customizable nbgrader with e2xgrader's Component-Based Architecture

- Different users have different requirements for nbgrader
- With e2xgrader's Component-Based Architecture, users can write custom plugins to change specific parts of nbgrader
- This approach avoids the need to maintain a fork of nbgrader
- Users can customize nbgrader to their needs without having to understand the entire nbgrader codebase



Authoring component

- Create assignment notebooks from collections of tasks
- Use a template to define the structure of the notebook (header, footer, standard imports)
- Version control for tasks to track changes
- Custom question templates
- Automatic id for questions



ASSIGNMENTS TASKS TEMPLATES

Task Pools

Instructions

Task pools are collections of tasks about the same topic. A task consists of a collection of related questions.

EXPORT

Search...

Name	# Tasks	Version Control
MC_Markov	8	Yes
MC_ZV_Stetige_Verteilungen	10	Yes
MC_Kombinatorik	5	Yes
MC_Descriptive_Statistik	14	Yes
MC_Bedingte_Wahrscheinlichkeiten	5	Yes
Testen	1	Yes
LinReg	1	Yes
MC_Testen	9	Yes
MC_Basic_und_FehlerBias	6	Yes
MC_ZV_Diskrete_Verteilungen	11	Yes

Rows per page: 10 1–10 of 12

ADD TASK POOL

ASSIGNMENTS TASKS TEMPLATES

Task Pools > Testen

Instructions

A task is a single Jupyter notebook consisting of a task with several questions (i.e. Task 1.1, Task 1.2, Task 1.3).

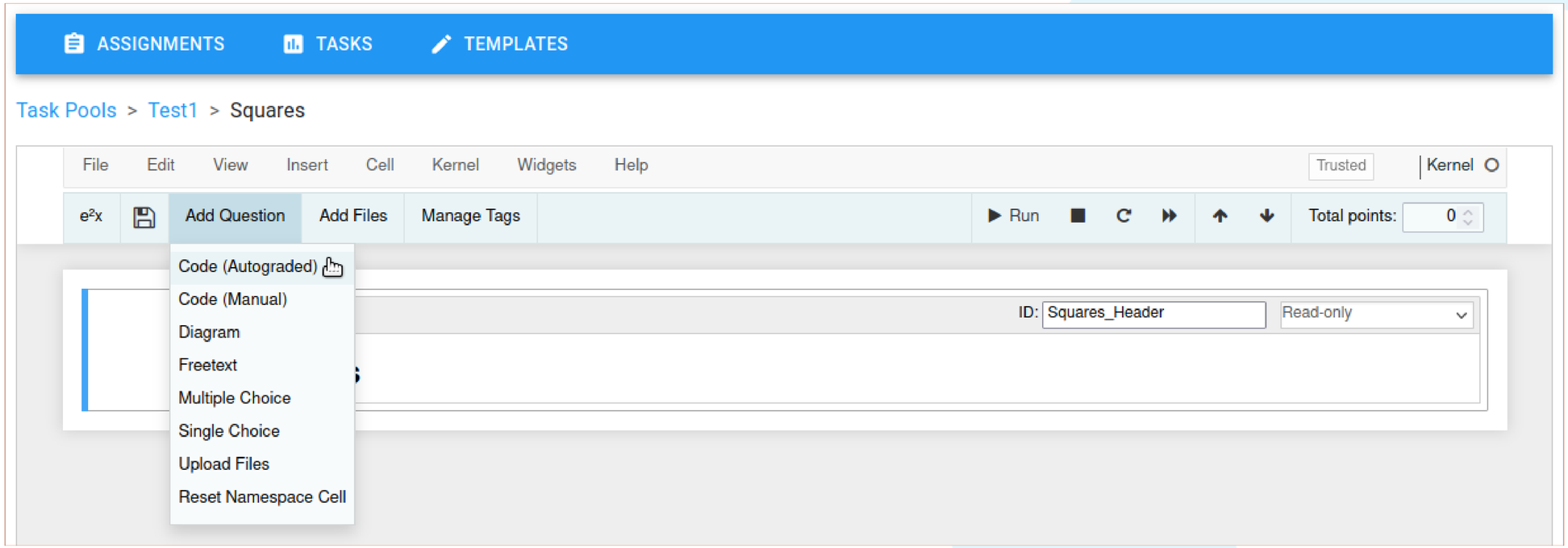
EXPORT

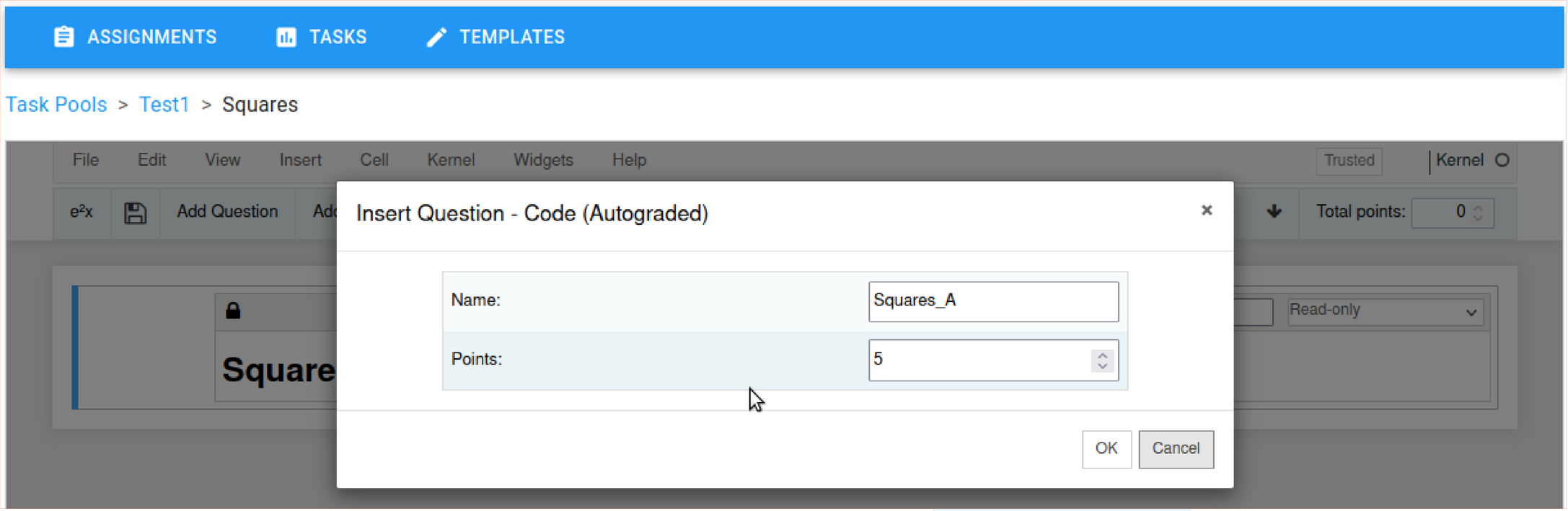
Search...

Name	# Questions	# Total Points	Version Control
t_Test	5	12	modified

Rows per page: 10 1–1 of 1

ADD TASK


ASSIGNMENTS
TASKS
TEMPLATES
Task Pools > Test1 > Squares
File
Edit
View
Insert
Cell
Kernel
Widgets
Help
Trusted
Kernel
e²x
Add Question
Add Files
Manage Tags
Run
Total points:
0
Code (Autograded)
Code (Manual)
Diagram
Freetext
Multiple Choice
Single Choice
Upload Files
Reset Namespace Cell
ID:
Squares_Header
Read-only


ASSIGNMENTS
TASKS
TEMPLATES
Task Pools > Test1 > Squares
File
Edit
View
Insert
Cell
Kernel
Widgets
Help
Trusted
Kernel
Add Question
Total points:
0
Insert Question - Code (Autograded)
Name:
Squares_A
Points:
5
Read-only
OK
Cancel

ASSIGNMENTS TASKS TEMPLATES

Task Pools > Test1 > Squares

File Edit View Insert Cell Kernel Widgets Help Trusted Kernel

e²x Add Question Add Files Manage Tags Run Total points: 5

ID: Squares_Header Read-only

Squares

ID: Squares_A_description0 Read-only

Question

Please write your question here!

In [ ]: ID: Squares_A Autograded answer

```
### BEGIN SOLUTION
# Answer

# Please write your code answer here!

### END SOLUTION
```

In [ ]: Points: 5 ID: test0_Squares_A Autograder tests

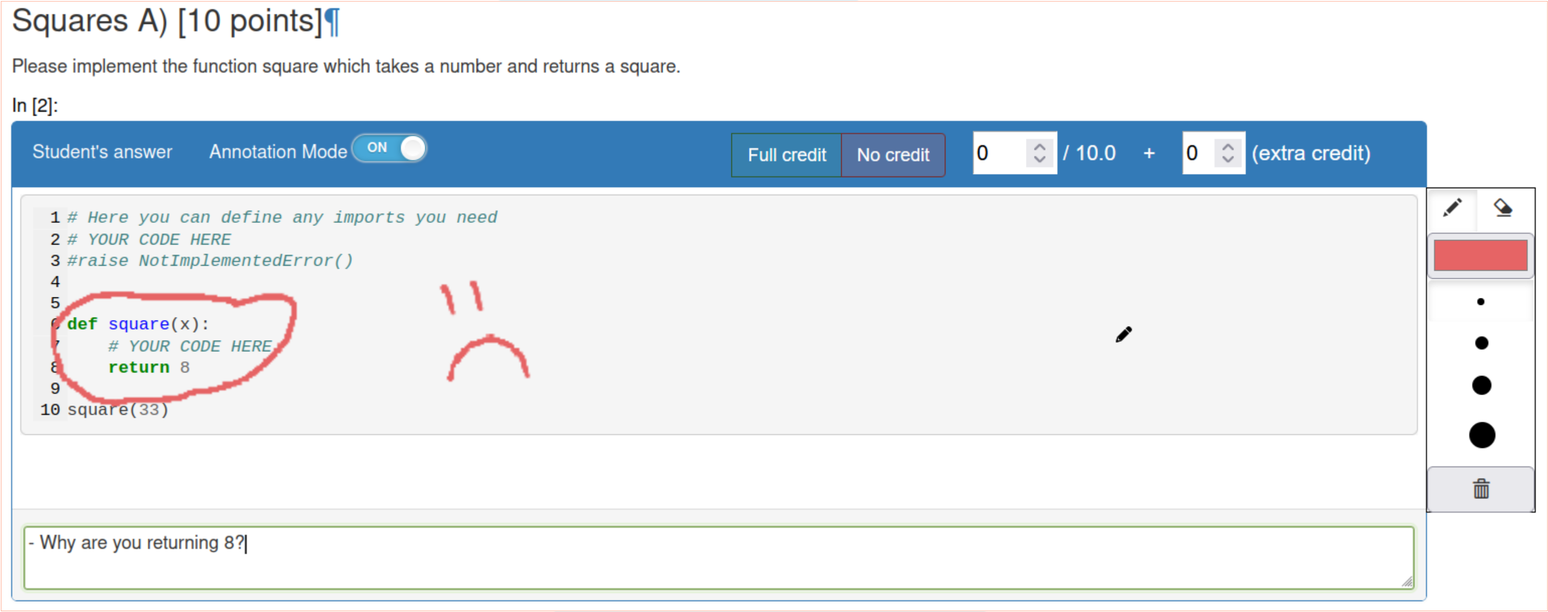
```
### BEGIN HIDDEN TESTS
# Test

# Please write your code test here!

### END HIDDEN TESTS
```

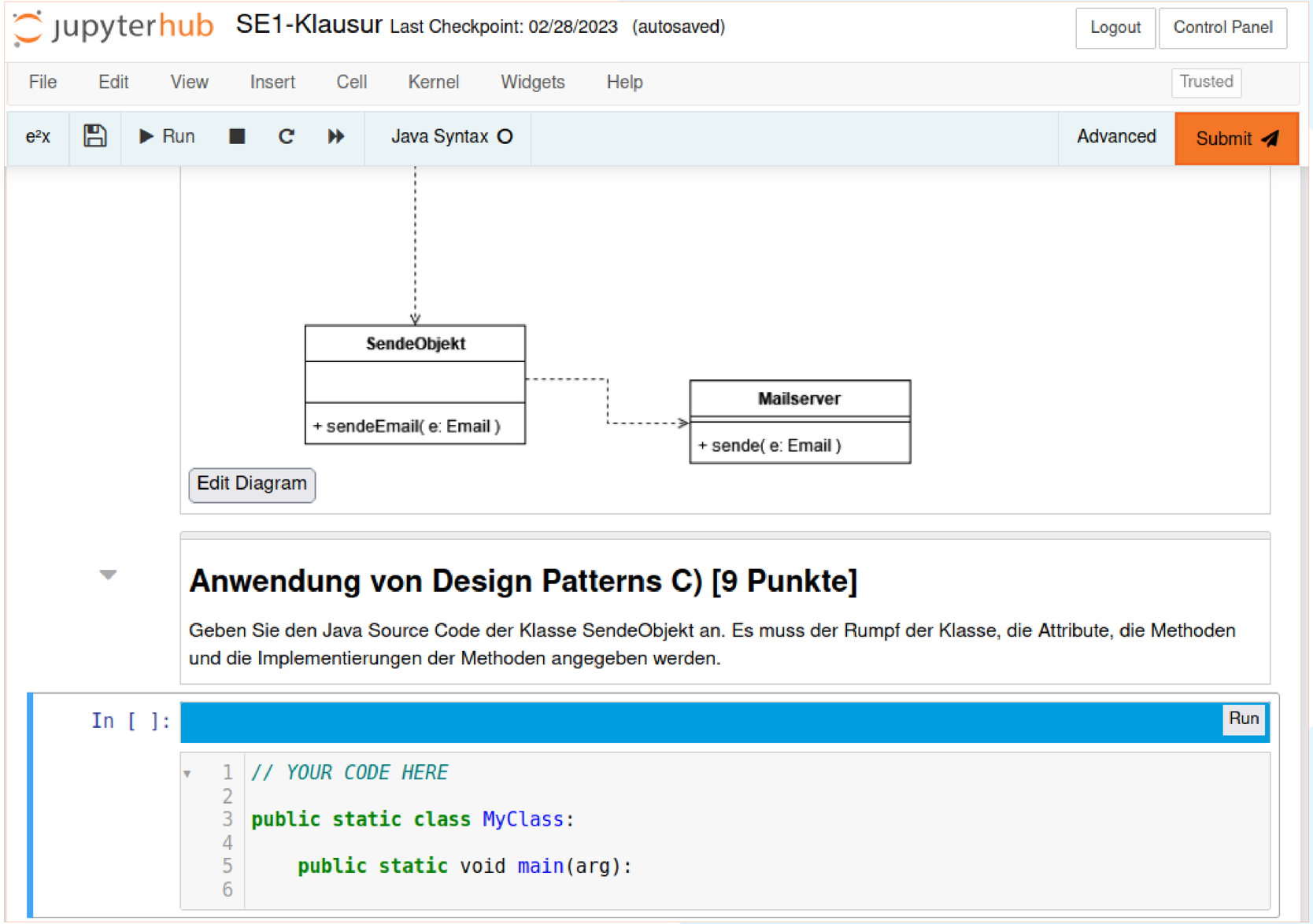
Grading component

- Add graders for new cell types
- Grading using a pen by drawing on the student solutions
- Per task grading view for easier grading
- Export student grades to csv

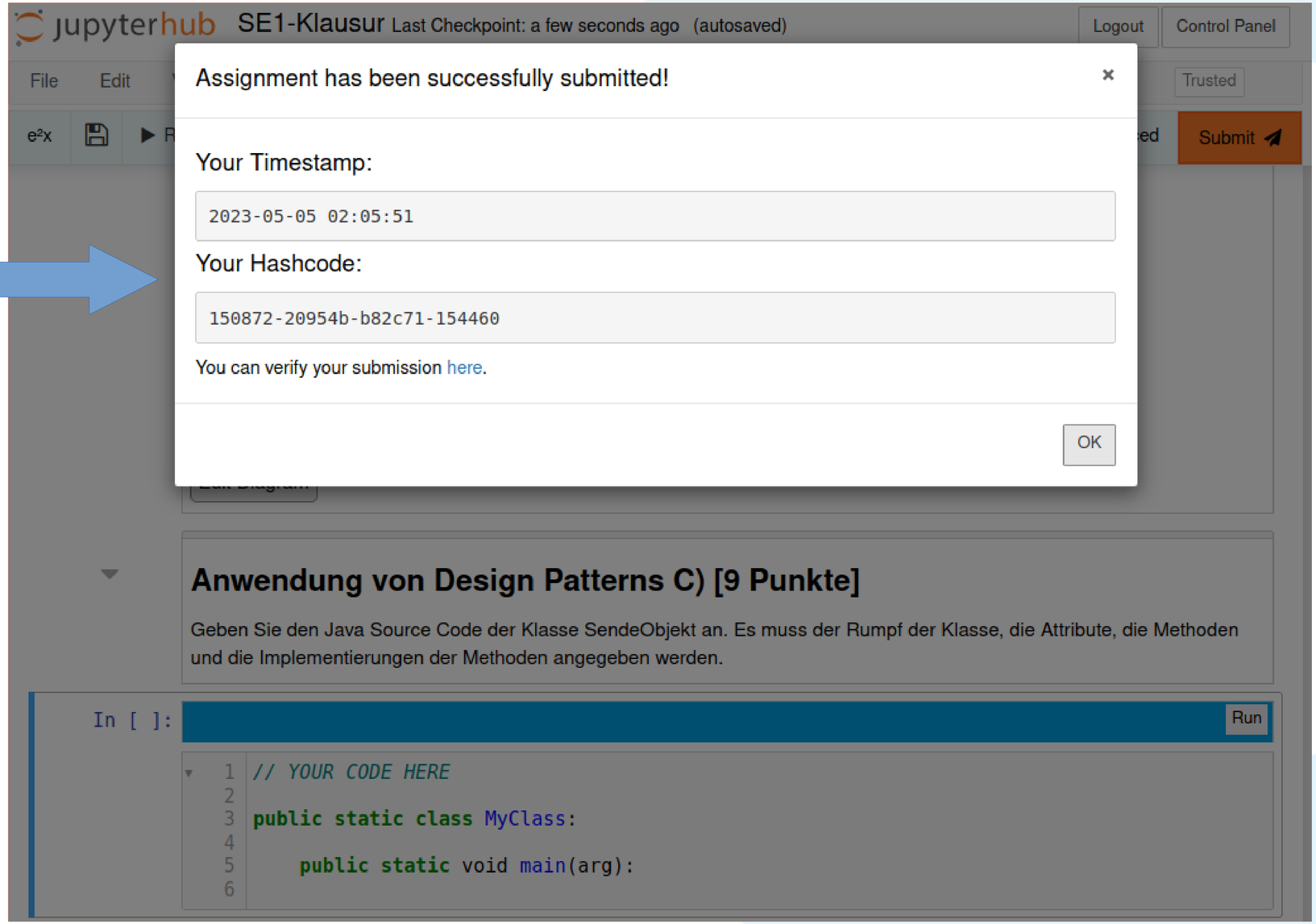


Student Exam Mode

- Students can’t delete notebooks via the frontend
- Students can’t modify the structure of a notebook
- Add toolbar for submitting within the notebook



Student Exam Mode



- Hashcode to guarantee the assignment is not changed during the grading process
- Students can look at a html copy of the submitted notebook

Summary

- New Cell Types
- Component-based Architecture
- Customizable Autograders

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Thank you for your attention!

CONTACT
Tim Metzler
Mohammad Wasil
Dr. Paul G. Plöger

Mail: e2x@inf.h-brs.de
github.com/Digiklausur