Using SageMathCloud for teaching undergraduate physics

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Contents

Background

Where, when & how!

Where?

- Physics & Astronomy
  - 500 students
- Cool Research
  - Astrophysics, particle physics, quantum computing, gravitation waves & more
- Teaching innovations
  - Dedication to improving education
    - Education research group

When?

- 2015
  - Transition from teaching C++ to python
  - Arrival of Jupyter Notebooks
  - The search for software
    - Jupyter Hub Server
    - University desktop
    - Sage Math Cloud

How?

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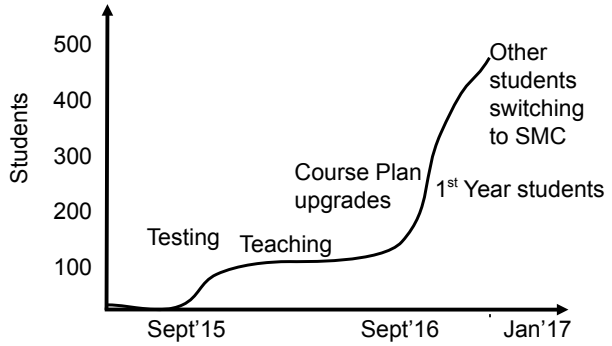
OPEN DREAMKIT

Our First Year of SMC

What happened?

Most of our students are now coding with SMC!



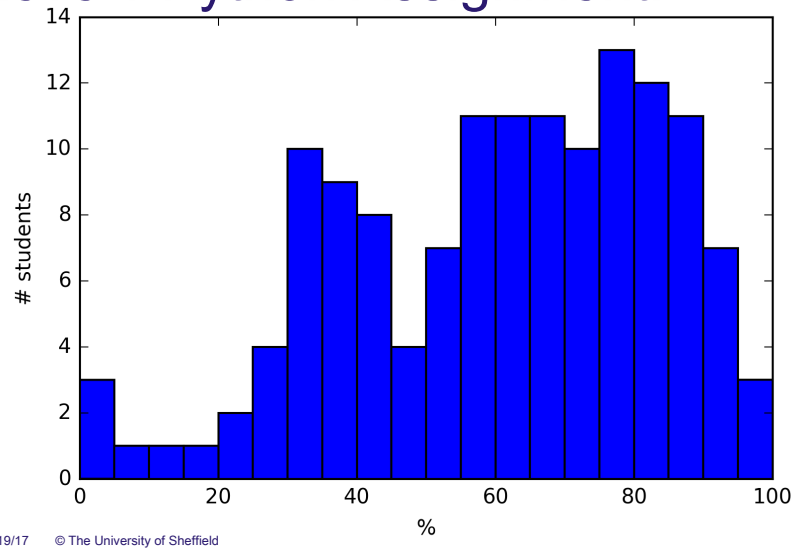
Level 1 students: introduce coding!

- New compulsory component via SMC course
  - Develop python tools for weekly data analysis
- Early in 1st semester
- ~200 students
- Risky:
  - Would students revolt!?
  - Would the system cope?
  - Would new staff cope?

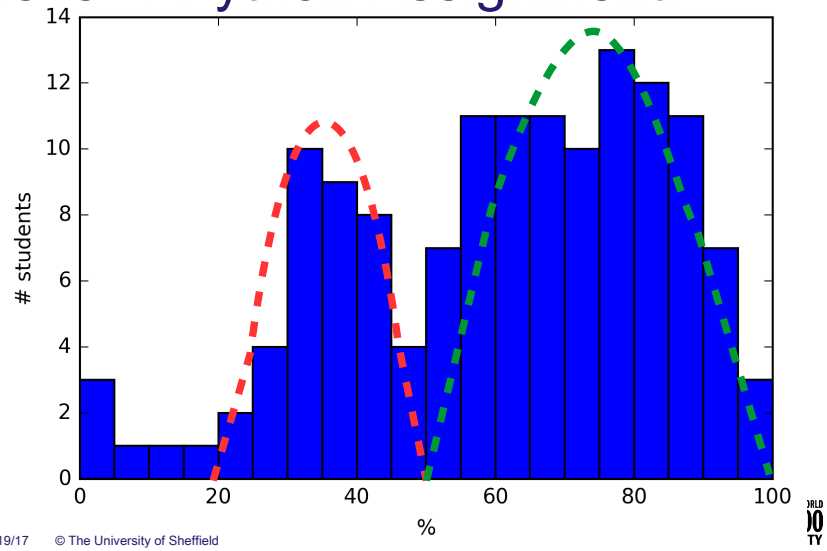
Level 1 students: introduce coding!

- Developed Jupyter Notebook
  - Tailored for zero coding students
  - Specific learning objectives
  - Follow example & task strategy
- SageMathCloud course
  - 3hr computer session
  - 2 week assignment + chat support
- Implement their code in weekly labs for data analysis

Level1 Python Assignment:



Level 1 Python Assignment:



Level 2 Courses

- Computational Physics
  - Numerical Modeling (Python)
  - Symbolic/analytical Modelling (Sage)
- Observational Astronomy
- Stellar Evolution
- Astronomical Spectroscopy
- Python Bootcamp
- Python Programming

Level 3 students

- Professional Skills in Physics and Astrophysics
  - Data crunching, stats, analysis
- Project work
  - Including group projects
- Advanced Python Programming

SMC in practice

- Purchased 2 large course plans (1 year)
  - Upgrades assigned to specific users (me)
  - Other academics add me to their project
  - I then attribute upgrades
    - Repeat for other courses/modules

SMC in practice

- Course management
  - Works like a dream
- Demonstrators are collaborators
- Students are added to course file
  - They sign in using uni-email (gmail)
- Assignments, marking and chatrooms
  - All great, had no problems

Its great but ...

- “Teaching using notebooks breaks the linear logic flow of conventional programming
  - Students get bitten and confused by execution order of cells”

Its great but ...

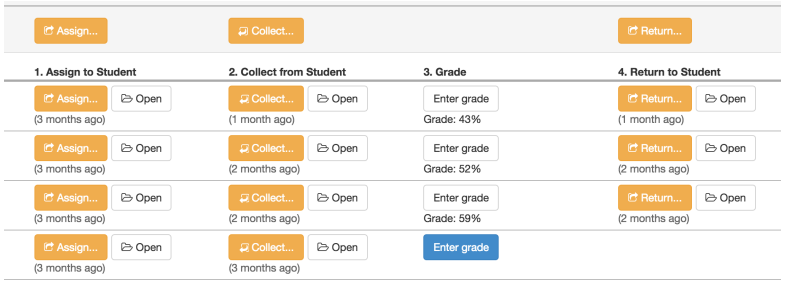
- No auto-close of notebooks.
  - “Students simply close the tab and so the memory usage rises until SMC stops functioning. Difficult to explain to students why this is bad”

Its great but ...

- “Relative links to filesystem assets break when notebooks are assigned - collected - returned with feedback”

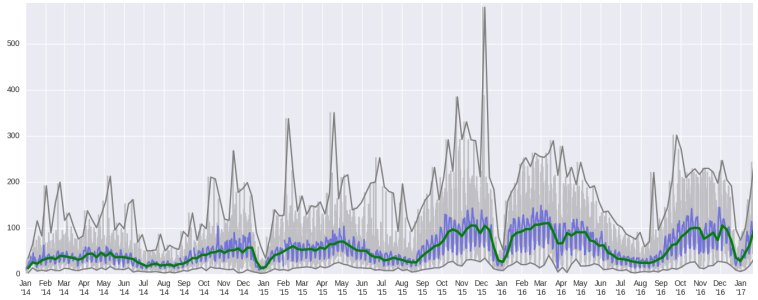
Its great but ...

- “Need to streamline the grading workflow”
  - Option to Grade and Click next within notebook



Its great but ...

- Make detailed analytics available to teachers
  - Individual students, full cohort …



A WORLD TOP 100 UNIVERSITY

The University Of Sheffield.

Our Education Research

A pedagogical study of Jupyter Notebooks

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The Shepherd Group

- New group at Sheffield Physics
  - Physicists researching education !
- Group created in 2015
- 3 academics
  - Initial research on use of Jupyter Notebooks

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Jupyter NoteBook Study

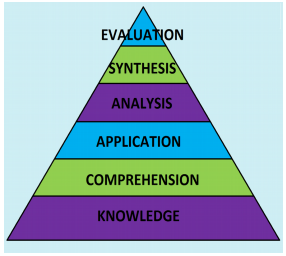
- Carried out by summer student
  - Jennifer Harding (Physics year 3)
- Test subjects:
  - Non physics students
- Interactive Jupyter Notebook
  - Interactive simulations, animations, code, text and images
  - Topic of waves in physics
    - From mechanical to quantum waves

A WORLD TOP 100 UNIVERSITY

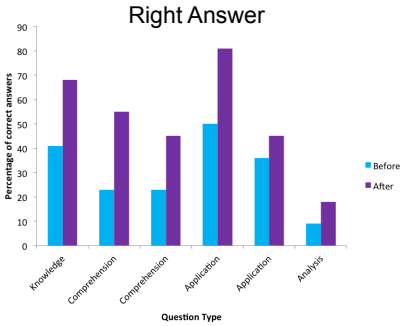
Pre-Screening	A questionnaire was sent to potential participants via email. A range of students (not physics) were chosen
Pre-Test	This took place in a controlled environment (computer lab – silence, no internet). A test with 8 questions was given to participants, with a 10 minute time limit.
Notebook Interaction	Participants were given around 20 minutes to interact with a notebook on the topic of waves.
Post-Test	The students were then given the initial test again under the same conditions.
Analysis	Learning gain was measured by comparing participants answers for each test.

Evaluation of learning

Questions devised to measure levels of learning

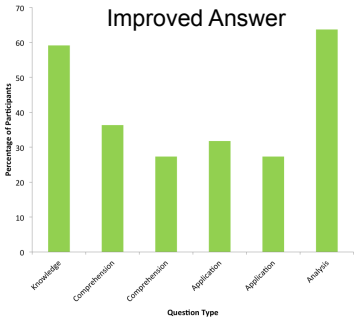


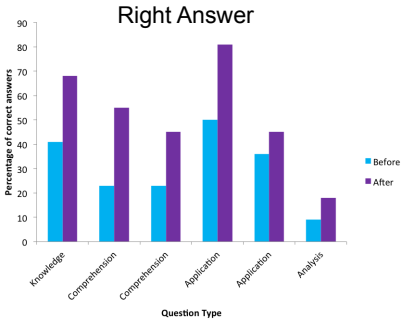
Blooms's Taxonomy



Learning Gain

Evaluation of learning





Jupyter NoteBook Trial

- Limit learning material
  - Cognitive load issues!
- Previous physics experience
  - With/without A-level
    - No apparent difference in results!
- Code
  - Subjects free to interact or not with code
    - Even for non coders, not an issue

Future Plans

Learn Physics thru Code

- Can we teach physics AND coding
  - … at the same time!?
    - YES!
- Can be applied to students with zero physics and coding experience
- Course management via SMC
  - Tremendous potential for local and distance learning
- Can SMC find use for pre-University education?

Get the most out of SMC

- Multi-core processing
  - Numerical projects are demanding
  - Need MPI exhibition on SMC
  - Incorporate optimised Python?
    - Cython, Numba
  - Stop students switching back to Spyder!

Start implementing GitHub

- Currently not widely used in physics dept.
- For student group projects?
  - See & track contributions
- Enable students to publish work
- Get academics to publish on Github too!
  - Disseminate teaching resources

Develop pedagogical studies

- Creating robust studies very challenging
  - How to create effective controls?
- Good news: less costly then physics experiments!
- Bad news: little education funding in UK
- Effective use of resources and community is key

Thank you

