REPORT ON OpenDreamKitDELIVERABLE D2.4

A short course for lecturers on using OpenDreamKit for delivering mathematical education.

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Due on	02/27/2017 (Month 18)
Delivered on	02/27/2017
Lead	University of Sheffield (USFD)
Progress on and finalization of this deliverable has been tracked publicly at: `https://github.com/OpenDreamKit/OpenDreamKit/issues/44`	

DELIVERABLE DESCRIPTION, AS TAKEN FROM GITHUB ISSUE #44 ON 2017-02-26

- **WP2:** Community Building, Training, Dissemination, Exploitation, and Outreach
- **Lead Institution:** University of Sheffield
- **Due:** 2017-02-28 (month 18)
- **Nature:** Websites, Media, etc.
- **Task:** T2.6 (#29)
- **Proposal:** p. 39
- **Final report**

SageMathCloud is both an open source software project (`https://github.com/sagemathinc/smc`) and an online instance of that software (hosted at `https://cloud.sagemath.com/`) that provides an interactive, collaborative environment for teaching and research in science, technology, engineering, and mathematics. SageMathCloud is used in teaching all over the world and a selection of courses utilising it can be found at `https://github.com/sagemathinc/smc/wiki/Teaching`. SageMathCloud predates OpenDreamKit and acts as prototypical example of VRE that can be built from the ecosystem OpenDreamKit aims at fostering; hence we are working in close collaboration with its development team.

In this deliverable, we have developed a short course for educators who wish to adopt this technology in order to enhance their teaching. Produced in collaboration with SageMathCloud developers and the wider community, the result is a website (`https://mikecroucher.github.io/SMC_tutorial/`) that can easily co-evolve with the technology it describes.

CONTENTS

1. Workshops

The first stage of evolution of the course material was to develop and deliver an instructor-led workshop for lecturers at The University of Sheffield. This workshop was delivered in June 2016 to approximately 20 lecturers, primarily from Sheffield's physics department. Feedback from the workshop informed future development and the workshop material became the nucleus of the current deliverable.

2. Course Website

We have produced a website, `https://mikecroucher.github.io/SMC_tutorial/`, containing a set of tutorials for educators who wish to adopt SageMathCloud in their teaching. The course material is developed in a style that allows it to be used for self-directed study as well as in instructor-led workshops. Access logs indicate that the GitHub repository hosting the material is visited by at least 40 unique visitors a week. This is in addition to visitors to the website itself that we currently do not measure.

In order to facilitate sustainability of the project, the website is developed on the open source collaboration platform GitHub, using a standard and open set of web technologies (Markdown and Jekyll). As such, it is possible for anyone in the world to comment on, contribute to, and collaborate with the project. Several individuals outside of the OpenDreamKit consortium have already made contributions.

The material has been adopted by the SageMathCloud development team and forms part of the official documentation.

3. Implementation at University of Sheffield

The University of Sheffield has been used as a testbed for both SageMathCloud and this tutorial material. Workshops have been delivered to educators from the departments of physics, biomedical sciences and computer science. In all cases, this resulted in the development and delivery of undergraduate and postgraduate courses using this technology stack. Highlights include 'Bioinformatics for Biomedical Sciences',which is currently being used by the University of Sheffield as a case study for 'excellence in teaching' (Appendix A and `https://www.sheffield.ac.uk/bms/teaching/stories/bms353`), and the departmental-wide adoption of SageMathCloud and Jupyter Notebook by the department of physics and astronomy who use it in several undergraduate courses spanning the entire curriculum.

Dr Mark Quinn, a University teacher from Sheffield, attended the 2017 OpenDreamKit dissemination workshop, Computational Mathematics with Jupyter (`http://opendreamkit.org/meetings/2017-01-16-ICMS/`). In his presentation (Appendix B and `http://opendreamkit.org/meetings/2017-01-16-ICMS/talks/SMC_Sheffield.pdf`), Mark notes that ALL current physics undergraduates (several hundred students) at Sheffield are now coding using SageMathCloud and that this process began with the workshop that eventually developed into the material that forms this deliverable.

4. Future Work

- Continue the collaboration with University Of Sheffield's physics department who is beginning to conduct research into the efficacy of Jupyter notebooks and SageMathCloud in teaching.
- Use this material to work with other departments within The University of Sheffield to expand the reach of this technology stack. Potential future collaborators include the departments of Architecture, Mathematics, and Engineering.
- Deliver workshops based on this material to Universities around Europe.

APPENDIX A. 27 FEB 2017, BMS353 CASE STUDY, UNIVERSITY OF SHEFFIELD WEBSITE

Department of Biomedical Science

BMS353 : Bioinformatics for Biomedical Science

Module co-ordinator: Dr Marta Milo

Using Jupyter Notebook in Undergraduate teaching

BMS353 is a newly introduced module in the Biomedical Science curriculum that has the scope to introduce students to Bioinformatics and Computational Biology for Biomedical Science, proving them with a set of skills to implement advanced data analysis. The key feature of this module is the introduction of biology students to interdisciplinary studies, with analysis of real case studies, which will be implemented with state-of-the art programming tools.

> Challenging but a great sense of achievement.
>
> **BMS353 STUDENT 2016**

It is aimed at biology students with little or no knowledge of programming and statistics and has the goals of: a) making them aware of effects of experimental design in the subsequent data analysis; b) having a good understanding of technologies and methods for Bioinformatics; c) introducing them to basic coding and use of workflow and pipelines for their data analysis.

In BMS353 the students learn with integrating theoretical knowledge with practical skills and the exposure to problem solving exercises helps them to develop innovative thinking. Interfacing mathematics, statistics and biology the students will acquire a set of skills that are unique and will make them competitive and highly employable.

> The hardest thing ever, stressful, frustrating but very rewarding.
>
> **BMS353 STUDENT 2016**

With this in mind, the key issues that we address in the module are: a) create an engaging and inclusive environment that enables effective learning of new skills; b) achieve learning using traditional lecturing techniques and classroom based activities with technology enhanced learning on a cloud based environment; c) design an effective way to assign, mark and feedback while enhancing constructive learning.

In delivery of this module, we focus on these key points:

- Easy working environment to enable students to naturally change their mind setting
- Interactive sessions in which monitoring learning with formative feedback
- Assignment that were able to assess learning
- Marking and feedback from teacher to students
- Peer feedback and problem solving using a dedicated discussion forum.

> Initially I found the learning curve rather steep, but in hindsight this was a good thing as it forced me to solve my own problems. This allowed me to learn how to use coding guides online, solve my own problems, and try out new ideas.
>
> **BMS353 STUDENT 2016**

The tools that we use through out the module are based on cloud computing and have a user-friendly approach to programming, using the Jupyter notebooks. This is to make learning a fun and enjoyable experience and to give the student a sense of achievement at the end of the module. Assessment is also based on interactive assignments.

The full assign-mark-feedback process happens through the cloud-based environment SageMathCloud and the practical classes are to stimulate discussion and to promote working in in groups. Students particularly liked this aspect. The module has a dedicated website interface for all the activities and forums for discussion and feedback.

The text word cloud below was generated by Mr Duncan Cooper, BMS353 (2015/2106) student, using the R coding skills for the data analysis to process words from his final project notebook.

APPENDIX B. 16 JAN 2017, USING SAGEMATHCLOUD FOR TEACHING UNDERGRADUATE PHYSICS, PRESENTATION AT OPENDREAMKIT DISSEMINATION WORKSHOP 'COMPUTATIONAL MATHEMATICS WITH JUPYTER'

Using SageMathCloud for teaching undergraduate physics

Mark N Quinn
Physics & Astronomy
m.quinn@sheffield.ac.uk!

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?

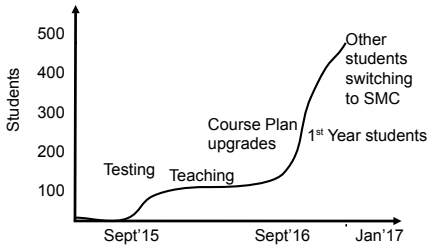
+

OPEN DREAMKIT

Our First Year of SMC

What happened?

Most of our students are now coding with SMC!



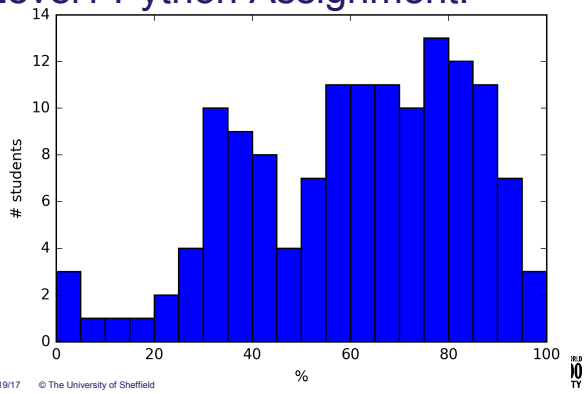
Level 1 students: introduce coding!

- 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?

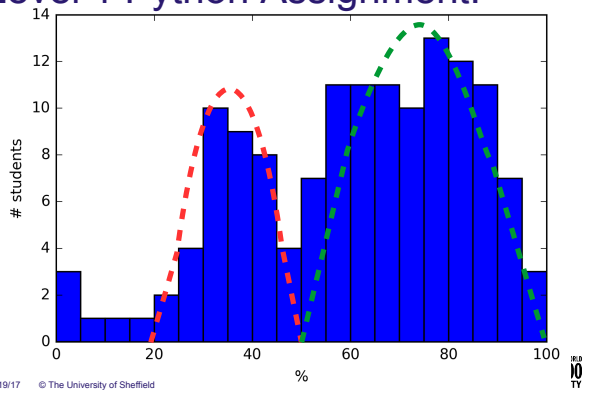
Level 1 students: introduce coding!

- 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 ...

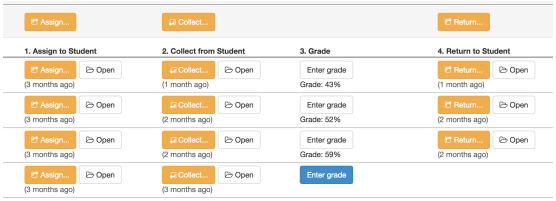
- No auto-close of notebooks.
  - "Students simply close the tab and so the memory usage rises until SMC stops functioning. Difficult to explain to students why this is bad"

Its great but ...

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

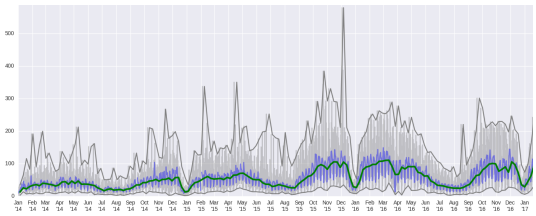
Its great but ...

- "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 …



The Shepherd Group

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

Our Education Research

A pedagogical study of Jupyter Notebooks

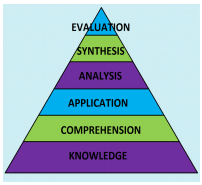
Jupyter NoteBook Study

- 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

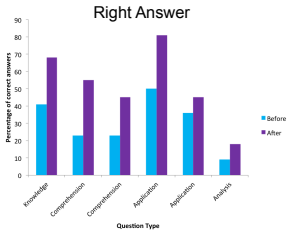
Pre-Screening	A questionnaire was sent to potential participants via email. A range of students (not physics) were chosen
Pre-Test	This took place in a controlled environment (computer lab – silence, no internet). A test with 8 questions was given to participants, with a 10 minute time limit.
Notebook 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

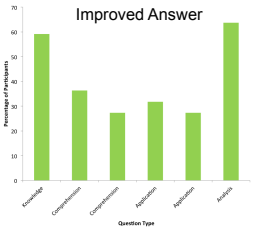


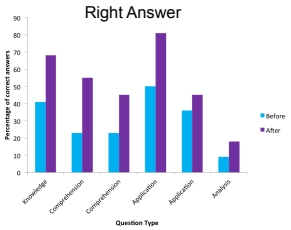
Blooms's Taxonomy



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

Disclaimer: this report, together with its annexes and the reports for the earlier deliverables, is self contained for auditing and reviewing purposes. Hyperlinks to external resources are meant as a convenience for casual readers wishing to follow our progress; such links have been checked for correctness at the time of submission of the deliverable, but there is no guarantee implied that they will remain valid.