Teaching our Students
Astro Computing
BoF B.6 – ADASS XXIX
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• Classroom experiences
  1. Martin Vogelaar, University of Groningen
  2. Peter Teuben, University of Maryland

• Your experiences

• Can we define a top 5 of skills we should learn our students?

• Should we maintain a repository of Python notebooks for astronomy education?

• Which future developments will become important?
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- Teaching astro computing:

  teaching students knowledge and skills to support their practicals and introduce them to data science

- Evolution in topics and teaching methods
- The necessity – past, current, future
- Benefits of sharing views and experiences
• Started with a course in 1997
  • Reason: skill levels varied too much amongst students

• Subjects
  • UNIX topics, command line utilities
  • Find your way on the local systems
    • network, printers, remote login
  • FITS
  • Creating reports with LaTeX
  • Plotting with SM (SuperMongo)
  • A bit of Mathematica
  • Short introductions to GIPSY, AIPS, IRAF
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• Tools
  • Local accounts (staff level)
  • Local hardware (no restrictions)
  • Involvement computer support group
  • Documentation on Internet pages
  • Oral introductions, assignments, project

• Notable
  • Every UNIX folder and most of the files were accessible to all
  • Material on Internet was copied (both ways)
  • Second year 2 ECTS (56h) course with on average 10 students
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• Big dip in 2001
  • Numerical analysis not mandatory
  • Programming not part of the curriculum
  • Attitude: students fill the gaps themselves

• After an ADASS (2000?) talk we started to introduce Python
  • Version 2.1
  • Used GNUplot for plotting (interface passing strings)
  • We trusted there would be a convergence of numeric, numarray, scipy-core → NumPy
  • Local stuff to read FITS files before PyFits 1.0
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• Course in 2019
  • Name: Introduction to Programming and Computational methods
  • First year, 5 ECTS (140h)
  • Documentation hosted on an intranet (prevent copies)
  • Still topics from Linux, LaTeX, FITS
  • Major part is mastering Python
  • Average between 70 and 80 students
  • Python material is astronomy focused right from the start!
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• Workflow
  • Getting to know the local environment (Linux, network, storage)
  • Introduction to tools: IPython, Jupyter Notebook, Jupyter Hub
  • Python basics
  • Packages (FITS, Plotting, numerical- and symbolic analysis)
  • Techniques (Rotation matrices, Fourier transforms, LSQ fitting)
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• Setup
  • 8 weeks course (5 ECTS=140h)
  • Short oral introductions each week
  • Practical work 3 x 3 hours a week
  • Tasks with assignments (notebooks checked by T.A.’s)
  • Midterm (written, not digital)
  • Final exam (digital)
  • Resits are projects in a notebook

• First steps using Nbgrader
• Notebooks integrated with SPHINX
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• 1. Notebook: Python for users of graphical calculators
• 2. Notebook: Python for starters
• 3. Notebook: Python sequences
• 4. Notebook: Types and conversions
• 5. Notebook: User defined functions
• 6. Notebook: Python sequences with numbers
• 7. Notebook: Simple visualization with Matplotlib
• 8. Notebook: Calculations with NumPy arrays
• 9. Notebook: NumPy arrays with random numbers, the basics
• 10. Notebook: Complex numbers
• 11. Notebook: NumPy and special numbers
• 12. Notebook: Functions (advanced)
• 13. Notebook: Object Oriented Programming basics
• 14. Notebook: Matplotlib, Object Oriented
• 15. Notebook: Matplotlib animations
• 16. Notebook: SciPy basics
• 17. Notebook: Symbolic mathematics
• 18. Notebook: Introduction to AstroPy
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• 19. Notebook: Reading data from text files
• 20. Notebook: N-dimensional data structures
• 21. Notebook: Visualization in 3 dimensions
• 22. Notebook: FITS files
• 23. Notebook: Linear Algebra
• 24. Notebook: Fourier Transforms
• 25. Notebook: Ordinary Differential Equations
• 26. Notebook: Exploring the normal distribution and Gaussian functions
• 27. Notebook: Linear Least Squares method and linear regression
• 28. Notebook: Non-Linear Least squares fitting, the basics
• 29. Notebook: Orthogonal Fitting with ODR
• 30. Notebook: Least squares fitting in the log(-log) domain
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• Results
  • Improved cohesion between practical courses (at least the astronomy courses)
  • Immediate application of skills to projects of other courses (Physics lab, EM)
  • Improved understanding of concepts such as Fourier Transforms
• Results (continued)
  • Evaluations by students are positive
  • Repository of notebooks also used by master students
  • Percentage of students want to learn C/C++ after course
  • Level of Bachelor projects has been increased
Some observations:

- Expectations of staff often not realistic
- Losing depth after adding more and more topics
- New students are not becoming less intelligent and are not poorly educated
  - Better language skills
  - Trained in cooperative learning
  - Used to modern (cloud based) tools
- Coordination with other courses is essential but difficult
- Support of system management is essential
- Education is subject to an increasingly number of rules
- Fraction of colleagues is skeptical but their concerns seem out of date
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• Future at Kapteyn
  • Need to shift relevant computational topics to the other courses that require it
  • We will lose computer facilities for students when moving to a new building
  • Perhaps we should move earlier to platform independent solutions
    • Physics department starts to use Google Colab
  • Youth hackathon seems ideal to get the attention of high school students interested in data science.
Future teaching astro computing
- Would like to see list with shared topics
- Availability of generic Jupyter notebooks for astronomy education
- Need to improve the link with data science