Teaching Dossier: Jonathan Dursi

In classroom teaching, I am particularly in computational science or introductory courses. Both require helping students learn the process of inquiry at least as much as helping them master the particular techniques or facts covered in the curriculum. My experience has convinced me that in these cases, going beyond lecturing, and experimenting with peer- and activity-based learning — while testing to see what works and what doesn't — has been valuable. Mentoring and supervising students requires many of the same skills, and I have had success with several such projects, resulting both in contributions to the literature, and the students' development as scientists.

Courses Developed and Taught

***CITA Summer School on Parallel Computing*, University of Toronto, Jul 2008**

With Jonathan Sievers (CITA), developed curriculum for and co-taught a week-long intensive workshop on parallel programing for computational science; hosted by CITA and the Department of Astronomy and Astrophysics, with support from IBM and Allinea.
http://pca.cita.utoronto.ca/.

AST222, *Galaxies and Cosmology*, University of Toronto, Jan-May 2008

A second-year course for physics majors; developed lectures and assignments from scratch based on a broad pre-existing syllabus. Taught with a TA. Received best course evaluations for teaching for past five years in this course. On basis of evaluations, was offered opportunity to teach it again in 2009.
http://www.astro.utoronto.ca/∼ast222/.

AST3100, *Scientific Computing*, Dept. of Astronomy & Astrophysics, Univ. of Toronto, Jan 2008

With Jonathan Sievers, created and taught a 4-week minicourse (1/3 of a credit) on Scientific Computing essentials for graduate students in the Department of Astronomy & Astrophysics. Topics covered essential coding tools, guidelines, linear algebra, ODEs, and PDEs. Attended by nearly many physics and almost all of the astro graduate students.
http://www.cita.utoronto.ca/∼ljdursi/minicourse/

AST3100, *Astrophysical Fluids Discussion Group*, CITA, University of Toronto, Jan 2005 - ongoing

Created and lead an interdisciplinary fluids discussion group based on current and classic papers; graduate students attending and participating in this seminar can receive credit as an astronomy graduate minicourse.
http://www.cita.utoronto.ca/∼ljdursi/astrofluids.html

Science 3211, *Search for Life in the Universe*, School of the Art Institute of Chicago, Jan-May 2004

Developed and taught new science course as breadth requirement for fine arts students; covered introductory astronomy, geophysics, chemistry, and biology. No TA. Used the textbook "The Search for Life in the Universe" by Goldsmith & Owen.
http://www.cita.utoronto.ca/∼ljdursi/SETI/.

Teaching Awards

D. McMinn Award for Teaching Outside of the University, May 2001

Award given annually by the University of Chicago Astronomy Department; received in part for my tutoring of South Side Chicago elementary/high school students.

Evidence of Classroom Teaching Accomplishments

Student Course Evaluations

AST222 is the only course I have taught recently with quantitative course evaluations that can be compared to previous years. Summaries of the course evaluations for this course for the past five years (and, spottily, before that) are available online from the Arts and Science Student Union at http://assu.ca/pages/anticalendar/theanticalendar.php.

My teaching scores for teaching this course for the first time were all the highest or tied for the highest from the past five years. Scores listed below are on a scale of 1-7, where 1 is 'extremely poor', 6 is 'very good' and 7 is 'outstanding'.

	2007-8 (ljd)	2006-7	2005-6	2004-5	2003-4
Presents	**6.1**	4.3	4.0	4.8	5.4
Explains	**5.7**	4.3	3.6	5.2	5.4
Communication	**5.9**	5.8	4.7	**5.9**	5.8
Teaching	**6.2**	4.8	4.4	5.6	5.5

Table 1: Teaching scores for AST222 over past five years, from ASSU anticalendar. 'Presents' - Presents the material in an organized, well-planned manner. 'Explains': Explains concepts clearly and with appropriate use of examples. 'Communication': Communicates enthusiasm and interest in the course material. 'Teaching': All things considered, performs effectively as a university teacher.

Student Evaluation Comments

AST222

Prof [sic] Dursi is very flexible in scheduling the course. His office hours is very helpful. Had great time in this course!

This course is somewhat more difficult compared to other astronomy/physics courses at the 2nd-year level. The instructor and the TA are great, and the course material is well organized. Adjustments should be made so that AST221 and 222 are more similar in difficulty and more connected in context.

Profs humour is appreciated, as was advice.

Dursi was very well organized and seemed genuinely interested in the students doing well and is very open to concerns about problem sets and workloads.

Professor cared about the course, which is nice, and for once I was able to keep up with a science math course

Parallel Computing for Astrophysics

Lectures explained key concepts clearly

[in response to, do you think you're leaving this course prepared to start parallizing codes?] Yes! With loads of bugs and mistakes at first, but learning and then [coding] immediately afterward was very helpful. I now understand other parallel codes better as well.

The lectures were great

Very helpful

I liked the emphasis on computing with applications

Wonderful job!

Very useful.

Good balance between science and computing.

The lectures were excellent; full of useful content, very clear and even fun.

I think I can start parallizing my code after the workshop.

[the hands-on sessions] were very helpful. Some stuff was hard, but enough to want to work more on it.

The topics were good.

Keep offering these types of workshops regularly!

Difficult, but I liked it.

Both Jon's are clear when they talk and patient, especially Dursi.

Definately feel like I can go home and start parallizing my code, at least in a basic way at first.

Lectures were very useful.

Development of Courses

CITA Summer School on Parallel Computing

Motivated partly by the upcoming SciNet supercomputing facilities that will be made available to University of Toronto researchers, and the utter lack of existing courses in high performance computing, Jonathan Sievers (CITA) and I developed and gave a week long course to given in the summer of 2008 to graduate students and new postdocs on Parallel Computing for Astrophysics.

All course development was planned around the stated goal: students should leave the course ready to start paralellizing their existing research codes. That is, we aimed to get the students over the initial hurdle so they could intelligently begin parallel programming, having enough background knowledge and a solid-enough grasp of the basics so that they could get started while learning on their own the things they need to work on their problems in particular.

The greatest challenge was choosing from the diversity of possible topics so that people working on a wide variety of problems would still find the material a useful starting point for their own work. We chose as a format an approximately one day introduction with students doing 'real' OpenMP parallel programming by the end of the first day, with the remainder of the time structured around three common astrophysical problems – hydrodynamics, n-body simulation, and map-making (data anlaysis) which were representative of the wide range of problems encountered in writing parallel codes for astrophysics. More generally, this also spans common hyperbolic and elliptical PDE approaches as well as linear algebra, so that this course is in fact considerably more general than astrophysics.

Each day consisted of two 90 minute lectures followed by two-three hours of 'hands-on' sessions (*e.g.*, doing related homework) to ensure that the students have a real opportunity to develop the relevant skills; programming and problem solving cannot be taught in a purely lecture format. We also included guest lectures on science empowered by parallel computing, a talk by IBM on future platforms, and another talk introducing them to other models of concurrency.

We were a little taken aback by the dedication of the students; they stayed through lunches and after hours working on their homework. Clearly there really is a real demand for learning these skills.

The instructors and organizers had a 'debriefing' after the class and discussed what we had learned from having the course; student responses were so positive that we plan to offer it again next year. Further, the resulting course materials – approximately 15 instruction hours hours and approximately 40 contact hours including associated homework/'labs' – form a reasonable starting point for development of a semester-long course.

Galaxies and Cosmology

This course already had much of a syllabus chosen (it is an intermediate level course; what the students know coming into it, and what they must know before going into the next course, is already determined), but had relatively little existing lecture notes, and a great deal of flexibility remained when I taught the course in Spring 2008.

Previous instructors focused greatly on galaxies and galactic dynamics, while not spending as much time on larger scale systems (galaxy clusters; cosmology). I chose a new textbook (with mixed results) and further developed the second half of this course.

Friday sessions of this MWF class were devoted to group problem solving and other activities such as using Google Sky as an exploration of multi-wavelength astronomy. Here I didn't use as many hands-on or peer learning type activities as it was a core course for majors, and thus I thought it was unnecessary; I'm now convinced that was a mistake, as those activities I did have the students do (with Google Sky, or working in pairs to try to understand Oort constants) were extremely successful in terms of the student reaction and retention of knowledge.

Although the students found the course quite challenging, the student evaluations were significantly more positive than in the previous year. With more peer-based activities in the Friday sessions and a better choice of textbook, I am hoping to make the course an even better learning experience when I teach it again in spring 2009.

Search for Life In the Universe

This was a very challenging course to develop, as it covered an extremely broad range of material for a student body with very little background in the subject area; further, scheduling posed a problem (this breadth requirement was scheduled as a single three-hour lecture on Friday afternoons).

As a result, this course demanded the inclusion of significant non-lecture-based approaches in the teaching.

This was the first time that I applied several Active Learning and Collaborative Learning techniques — both to keep students involved, and to get more feedback about student learning through the course. Absent real lab facilities, microlabs during the three hours and quick writing assignments helped serve the joint purposes of allowing the students to explore the material, collaborate, and stay involved during the afternoon. Because of the variety of material we covered and the relative inexperience of the students, there was often a great disparity between students' ability to absorb the lecture material, with different groups of students 'getting it' depending on what the topic was. In this case, collaborative or peer-based activities worked extremely well for improving all of the students understanding of the material.

Results of final testing of students on questions not only of the course material but of larger "how science is done" issues was extremely heartening, particularly when compared to pre-testing of similar 'big picture' questions. Course reviews were uniformly positive.

Mentoring and Supervising Students

Undergraduate summer project: A. Ingle

With N. Ivanova (CITA): undergraduate student K. Robinson, summer 2008. Project title: "Strange remnants of stellar collisions".

Ph.D. Thesis: L. Mudryk

With Professor N. Murray: thesis project of graduate student L. Mudryk, 2005-7 (who won Best Student Poster, MITACS/CAIMS 2006). Thesis titled "Planetary System Evolution: Planet-Disk Interactions and Planet Ejection from Binary Systems".

Ph.D Summer Project: K. Kratter

With Professor U. Pen: summer project of graduate student K. Kratter, 2007. Project title: "Magneto-Rotational Instability in Stellar Geometries"

Undergraduate summer projects: D. Doucette, C. Hiratsuka

Undergraduate students D. Doucette, C. Hiratsuka, summer 2005. Project title: "Ignition Problems – hotspots and crushing – in Type Ia Supernovae."

Undergraduate summer project: K. Robinson

Undergraduate student K. Robinson, summer 2003. Project title: "Morphology of Hydrodynamic and Magnetohydrodynamic Buoyant Bubbles".

Undergraduate summer project: J. ZuHone

With M. Zingale: undergraduate student J. ZuHone, summer 2001. Project title: "Maintaining Equilibrium in Stratified Atmospheres in Finite-Volume Methods"

Teaching Philosophy

General Science Education

Because the importance of the scientific process extends far beyond laboratories and academic journals, so must the teaching of that process. Being skeptical, testing understanding against data from the real world, and being open to the possibility that one's understanding may fail that test — these are skills with wide application to understanding our world, and which are valuable to all. Part of our job is teaching the scientific approach – to understanding problems and searching for their answers — to students who will go on to careers very different than our own.

This understanding has shaped my ideas of teaching science, especially at the introductory level. It's the scientific process that I've tried to capture – whether teaching a course to new or non-science students, who are seeing it for the first and maybe the only time; or introductory computer programming courses, where abstract problem solving is a similar process; or in supervising undergraduate students through their first serious research projects, where they finally get to apply the process to novel work.

Computational Science

This process approach is equally relevant in computational science courses, which too often focus exclusively on programming techniques and lists of algorithms. These are important, and must be taught, but the process of doing computational science is more than editing and compiling a code until it doesn't have any obvious bugs.

Experimental science has had a long time to discover how best to train new practitioners — how to convey the importance of design of experiment, integrity of results, and reproducibility to incoming students. Computational science is much newer, and hasn't had as much time to develop a canon of material for all incoming students to study. But computational science can learn much from the history of experimental science education. Many of these ideas are just as applicable to learning to do computational science well. The importance of keeping logs; continual testing; 'equipment' design; and presenting enough information for other groups to reproduce the results.

Techniques

The importance I place on teaching the process of science as well as a body of knowledge strongly informs how I've approached teaching. Carefully crafted lectures can convey a lot of facts — and it is certainly important for the students to learn those facts — but one can't simply lecture a process. A lecture format is useful for delivering lots of information, and allows the lecturer to demonstrate working through a problem, or to frame difficult concepts for the class. On the other hand, it means that the students role is largely passive, so that attention span is short and retention is low. This is especially true if the same array of facts is available in the textbook.

Many of these points were driven home for me when, from in 2004, I created the curriculum for and taught a class entitled 'The Search For Life In The Universe' at the School of the Art Institute of Chicago. Since this was likely the only science course these students would take through their degree program, the breadth of the course topic was in some ways ideal; the course touched on astronomy, geophysics, chemistry, and biology. However, scheduling challenges (a science course scheduled as a single 3-hour lecture session on Friday afternoons!) as well as the course material made it essentially mandatory for me to include some non-lecture-based approaches in the teaching.

This was the first time that I applied several Active Learning and Collaborative Learning techniques — both to keep students involved, and to get more feedback about student learning through the course. Absent real lab facilities, microlabs during the three hours and quick writing assignments helped serve the joint purposes of allowing the students to explore the material, collaborate, and stay involved during the afternoon. Because of the variety of material we covered and the relative inexperience of the students to science, there was often a great disparity between students' ability to absorb the lecture material, with different groups of students 'getting it' depending on what the topic was. In this case, collaborative or peer-based activities worked extremely well for improving all of the students understanding of the material; in testing, the material covered by such activities invariably showed better retention and comprehension by the students, teaching me something about the usefulness of these techniques.

In teaching computational classes, the opportunities for useful activities and collaboration present themselves more easily, so finding and developing these activities is less of an issue. However, computing classes have their own challenges. I've already mentioned the lack of emphasis on the process of inquiry; another neglected process is debugging. While effort is put into the teaching the problem solving process of putting together an algorithm, very little is generally spent on the quite different problem solving process of fixing your implementation of it. I have put together some materials on debugging that I try to work into any basic computing course. Indeed, I've found that interactive debuggers are extremely useful at very introductory levels, as they demonstrate quite clearly what elementary constructs do, while also introducing students to a tool with which they will soon become all too familiar.

An increasingly important set of tools for computational science that is rarely covered in a student's undergraduate training is parallel computation. Throughout my mentoring and supervising experiences I have helped several students, undergraduate and graduate, become proficient with the necessary concepts and techniques on an individual basis, but with the growing availability of parallel computing resources, it's becoming important that the instruction, too, scale upwards to larger numbers. This culminated in the putting together of the Parallel Computation for Astrophysics workshop in summer 2008.

At a more advanced level, I also currently lead a seminar on astrophysical hydrodynamics, attended by graduate students, postdocs, and faculty; and one for computational astrophysics is soon to follow. This is a much different experience; although there is some teaching involved (in making sure the material is accessible to the newer graduate students while keeping it interesting for postdoc and faculty) and some preparation required, it is much more of a collaborative exercise.