

Teaching Statement / Philosophy for E. Jason Riedy

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When teaching, I want the students to feel in control of their learning. I find this engages students more thoroughly than simply presenting material, leading to greater personal investment and better outcomes. But this takes different forms in different scenarios. For example, semi-guided research classes are different than core mathematics classes. Students in the former are self-selected and already feel some semblance of control. Core classes are “forced” on students. Leading them into feeling some control, or at least understanding *how* they can control learning even without controlling the topics, has larger impact. Methods for assessment also differ widely.

I immediately could teach courses in linear algebra, arithmetic and numerical analysis, system performance evaluation, high-performance computing (HPC), and parallel algorithms. With some lead time, my background in linear algebra and mathematical optimization opens up many options in introductory machine learning. Similarly, my experience with HPC and novel computing architectures lead to operating and run-time system courses.

Moving forward, I would like to construct curriculum around high-performance data analysis (HPDA), which applies HPC and machine learning to interesting applications. This area has real-world impact even at smaller scales. Choosing example applications carefully can attract a more diverse collection of students, as I’ve seen in my BeeSnap class and in others (*e.g.* similar classes examining city and urban planning). “Broadening participation in computing” is far more than an NSF proposal requirement. In-class example applications of direct interest and visible results appears effective in reaching and retaining students from under-served groups.

1 Research-Oriented Classes

My undergraduate time (along with summers during high school) heavily involved research with classes, so I try to reproduce the best aspects I remember. At Georgia Tech, I partnered in starting two undergraduate research classes with interesting contrasts and similarities. Both are Vertically Integrated Projects (VIP) courses¹ that permit multi-semester interaction with returning undergraduates (and occasional masters students). One class has a strong inter-disciplinary focus and wide appeal. The other is much more focused on computer systems and architectures. Both have shown value in having students control their own learning and tasks even when guided by higher-level project objectives. Students become energized and passionate (sometimes) about the topics. And then they recruit more students. Students are the *best* recruiter of other high-quality students. I haven’t seen funding / pay recruit students of the same caliber. Note: Some of this also is included in my research statement. I do not see research as separate from education. One of research’s goal is to educate.

1.1 BeeSnap: Research into Honey Bees and other Pollinators

One class with Dr. Jennifer Leavey began in 2015 and focuses on pollinators including honey bees. This obviously is the course with wide appeal. This course has included over 60 undergraduates from over 13 majors over its history. Almost all students return for at least two years. A few participated for their entire four- or five-year time at Georgia Tech, using both core and free electives to contribute. Longer term students lead the newer students and educate them on methods and mechanisms. Returning students show newer students that research is not an instantaneous process but requires time. Since teaching is one of the best ways to learn, they leave with strong backgrounds in many areas as well as skills in working with multi-disciplinary and diverse teams. Our observations are backed up by wider analysis across all of Georgia Tech’s VIP courses².

As the advisors, we provide higher-level goals, form subgroups, guide subgroup tasks, and ensure progress. Weekly short status presentations in front of the *entire* class of what was accomplished and what is planned

The wide appeal of the application area, honey bees and pollinators, also attracts many more women and minorities into a computing-oriented class than appears typical. That there is an obvious natural impact and massive economic impact³ also helps students invest themselves in the area. Given them some control over their own directions massively magnifies that investment.

¹See <http://www.vip-consortium.org/formoreonVIP>

²Data and citations at <https://www.vip.gatech.edu/proposals>.

³The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) in 2017 valued the annual global contribution of pollinators to crops at \$235 billion to \$577 billion. <https://ipbes.net/assessment-reports/pollinators>.

Another interesting aspect about our pollinator project, BeeSnap, is exposing computing students to biologists' field work and biologists to what computing students development process (picking a relevant subset of involved majors). Computing students often only see data sets assigned in homework and not the process needed to obtain them. The biologists see computing as application and not as development. The civil and environmental engineers, public policy majors, and others also provide unique insights the students would not obtain in their own major's courses nor in more general open electives. Projects include citizen-science phone apps, IoT instrumentation of bee hives, evaluation of materials for native bee habitats, GIS analysis of pollinator-friendly trees, field work to sample bee interactions, and more.

Our undergraduate research class also has produced results in terms of students. Some have gone on to Masters degrees, some have gone into city government, *etc.* Almost all have external internships that apply similar ideas to other data. Some are employed by USDA-funded summer projects involving honey bees, outreach, and education. I was privileged to have a student send a "thank the teacher" award my way, and many ask for letters of recommendation. Notably almost all the involved students *deserve* recommendation. The students take the mantle when given the opportunity to have wide societal impact.

1.2 Rogues Gallery: Novel Architectures for Novel Problems

The other class is on the novel architectures in Georgia Tech's Rogues Gallery (see my research statement) co-lead by Dr. Jeffrey Young. This class begun only in spring 2019 already has its core of returning and engaged students. Here undergraduates are exploring neuromorphic, analog, quantum, and data-centric computing platforms. Many of these platforms are only "partially baked" if even heated at all. This is not a typical experience for undergraduates who use only the operating system pre-installed on their laptops or other systems. Many only just are taking operating systems and/or hardware classes.

We have lost students who did not realize they were not sufficiently prepared, and we have learned to rephrase the requirements and provide better on-ramps into the material / research. This has informed our external Rogues Gallery tutorials.

But the returning and new students posses amazing enthusiasm. After updating the tools for our local field-programmable analog arrays, the neuromorphic / analog team re-purposed themselves onto a direct application: using neuromorphic computing to make the Georgia Tech rally car (AutoRally⁴) energy efficient and altogether better.. The student working on the Emu Chick, a partitioned global address space migratory thread platform, focused on unimplemented primitives of collective parallel computing like prefix sum operations. And the students focused on quantum computing founded Georgia Tech's new (as of fall 2019) Student Quantum Computing Association⁵. They initiated this on their own as they discovered that the student quantum resources are too spread out at GT. (I currently am the association's faculty advisor and have encouraged them with praise and resources.)

I am seriously impressed. The BeeSnap team took longer to ramp up to being semester-to-semester productive but involves students of far more diverse backgrounds. The Rogues Gallery class took one semester to coalesce on topics that are timely and publishable. On the flip side, many students in this class want to jump out of a multi-semester research class and into the research projects more focused on the topics, endangering the classes long-term feasibility. I still am considering how best to support the students' needs.

1.3 Pedagogical Observations

- For mechanism, short weekly progress presentations to the entire class motivate, educate, and help assess. Peer pressure can be useful if structured respectfully. And reminding students that their presentations (and research notebooks) are useful for not only course assessment but for letters of recommendation makes a large impact. And by the end of a semester, even most people reticent to present join to explain their portion, often enthusiastically because they have received peer support and recognition.
- Be patient. Students have their own goals. Unpaid undergraduates in particular likely have no reason to obey your needs. You can learn much from their directions and interests, but you also can motivate overall directions. The interplay is useful for building larger research projects to be proposed to funding agencies with their own directions and interests.
- Students know more than you about the current tools. Roll with it. They feel more invested when they can choose

⁴<https://autorally.github.io/history/>

⁵External web site not ready for advertising, but will be by spring. Contact me for the URL.

their own tools, particularly when they bring other students up to speed.

- Great students recruit and retain great students. They speak the same language and roughly inhabit the same academic circles. This also happens for lecture-oriented classes but is far more obvious in research-oriented classes.
- *Applying* computing to the world appears more interesting to underrepresented groups. This may have grown from many reasons, but we can use the observation to *learn* those reasons and address them.

One outstanding challenge in multi-year undergraduate resources is how to track contributors over time to credit them appropriately in any publications. Students graduate or simply leave the course for various reasons. Keeping in touch is difficult.

2 More Formal, Lecture-Oriented Classes

There are many perspectives on how useful traditional lecture classes are for student learning. My view is “it depends.” The more formally structured courses I have constructed were for an audience who immediately would tune out a flipped classroom or other non-typical structure. But there are other methods for empowering the students and helping them see they can control their own education.

This section is more autobiographical than most would recommend. Once I left UC Berkeley, I was in coal country for family reasons. The place where Virginia, West Virginia, Tennessee, and North Carolina meet was, for me, eye-opening. Coal and tobacco and health care country. The two educational concerns were trying to make do and trying to get out.

I was adjunct faculty in mathematics at Virginia Intermont College⁶. I had to construct rapidly one core mathematics course and one related elective because of unfortunate circumstances⁷. My only given material were the two textbooks. The other mathematics faculty member wisely was not invested in the college.

The larger of my two courses was the only required mathematics class in most majors. The students almost all were seniors expecting to graduate. The textbook I had included such topics as adding fractions. The students could not translate “on sale for $X\%$ ” into algebra or even arithmetic. This was and hopefully will be my most difficult teaching position.

I kept this class in fully tradition lecture format; anything else would have terrified the students. But my lectures were not constrained to their textbook. Two of the three days in the week covered the textbook in a somewhat accelerated manner. On Fridays I went into more detail. I explained the history of what we covered trying as well as I could to emulate Eli Maor’s light but thorough style. One time I explained Peano’s axioms although by stacking rocks rather than bags-within-bags. Then roughly described constructing the integers and rational numbers. Learning that *people* made (or discovered) numbers encouraged quite a few students.

This region is steeped with oral history. Most driving or walking directions involve turning at so-and-so’s house which hasn’t been there in ages. Supplying *history* seemed to help in multiple ways. One page in a textbook becomes a progression of ideas *from people* over possibly hundreds of years. There is no magic. Just people. And there are plenty of dead ends. So if something seems difficult to understand, you’re in good company. Only took decades or centuries.

While students progressed, their final scores still fell along a perfect bell curve shifted far to the left. Sometimes compromises for the environment must be made. They had learned some things. And I received the best compliment from a student that I consider possible: “I’m no longer as afraid of math.” That complement was *after* grades were finalized but before the students knew their grades.

My other class was mathematics for future elementary school teachers, required for their certification. I had two students. Neither went on to teach. There were few to no children of elementary school age where they lived at the time (decently outside Bristol). With two people and knowing their situation, we could wander a bit. I explained that “elementary” is not an insult; “elementary” means built from known elements. If I recall correctly, that was during our third class.

The tone changed immediately. I admit that I used these two students to discover approaches for the larger class. I explained the Pólya’s problem solving principles. I tested my explanation of Peano’s postulates, first with stacking rocks and then with bags, so I stuck to the rocks. I also remember going on a tangent during the logic portion and explaining how half- and full-adders function. Neither student is in a position where this knowledge has immediate impact

⁶Which lost accreditation and went bankrupt, deservedly.

⁷Materials still at <http://sonic.net/~jriedy/VI/math131-f08/> and <http://sonic.net/~jriedy/VI/math202-f08/>.

(according to our social network connections), but the look in their eyes had immediate impact on me. Computers are based on this?

People want to understand. Sometimes they sublimate this desire for immediate needs.

2.1 Pedagogical Observations

- Lectures can be comforting in their structure. Throwing young students into “flipped” classrooms could make them tune out. Much of this is playing the audience. For example, if you see a student is confident, have them explain their work. That builds peer respect and camaraderie. Calling on those who are not confident only can work if you already know they have it. Otherwise it’s a punishment.
- History provides perspective. Ideas are not magic. They come from effort, much more effort than a homework assignment. Understanding may require centuries the first time. Having a few days’ confusion is perfectly fine.
- Alas, in the larger required course, I had to partition students into those who listened and those who did not.
- Explaining that mathematics (and computing) are inventions of **people**, and showing *how* they were invented changes students’ views of the world.

3 Summary

I feel that guiding students towards realizing that learning is a process they can control and guide has **no** drawbacks for the students. For the instructor, the personal investment can be costly as well as how it feels when the approach does not work for some students.

There are other educational formats that have presented challenges. Guest lecturing forces all your methods into one or a few class sessions. Presenting external tutorials similarly restricts you to only a few hours at best. Guest lecturing is more straight-forward: the goal is educating the students. External tutorials are as much advertising as educating. And guest lectures are more ephemeral, while tutorials often require longer-lasting materials. I still am adapting for these, but always with a focus on empowering students. Tutorials are interactive. Guest lectures should fit into the individual course’s structure.

And there are challenges I have yet to face personally. One graduate student approached me with her situation. The students seem actively antagonistic, and the instructor is new faculty, young, foreign, and a woman. As presented to me, the students carefully are parsing Georgia Tech rules and trying to bait a response. While I strongly suspect this scenario will not happen to me in the US (experienced, native citizen, male, rather privileged), I need to find some useful way to assist both fellow faculty and teaching assistants. Simply showing up and glowering could work, but it shouldn’t and would not build the appropriate future interactions.

Overall, my days with our students are the ones that invigorate me. The GT students can be amazing. And the students who were at Virginia Intermont still provide me with amazing memories. When they not only understood but realized that the material was a part of peoples’ history, their outlook changed. They would ask questions (occasionally). They would not see the instructor as separate but as a part of the entire process.

As I was told by Prof. Kahan at Berkeley, “[a] student’s job is to teach the teacher.” I’m still learning and do not want to stop. I look forward to what I learn.